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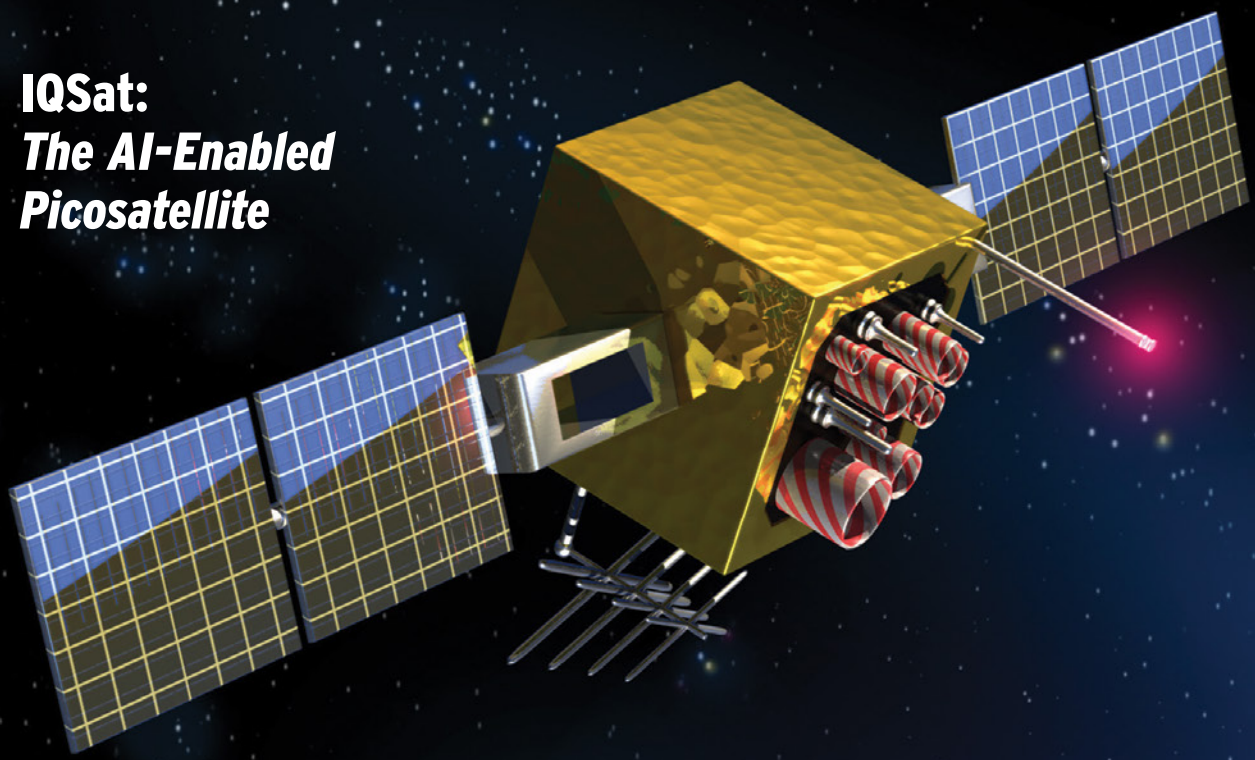

IQSat: *The AI-Enabled Picosatellite*

NearSpace Launch: Rapid Production of Spacecraft

Transforming Satellite Antenna Technology

Space-Based Laser Communications

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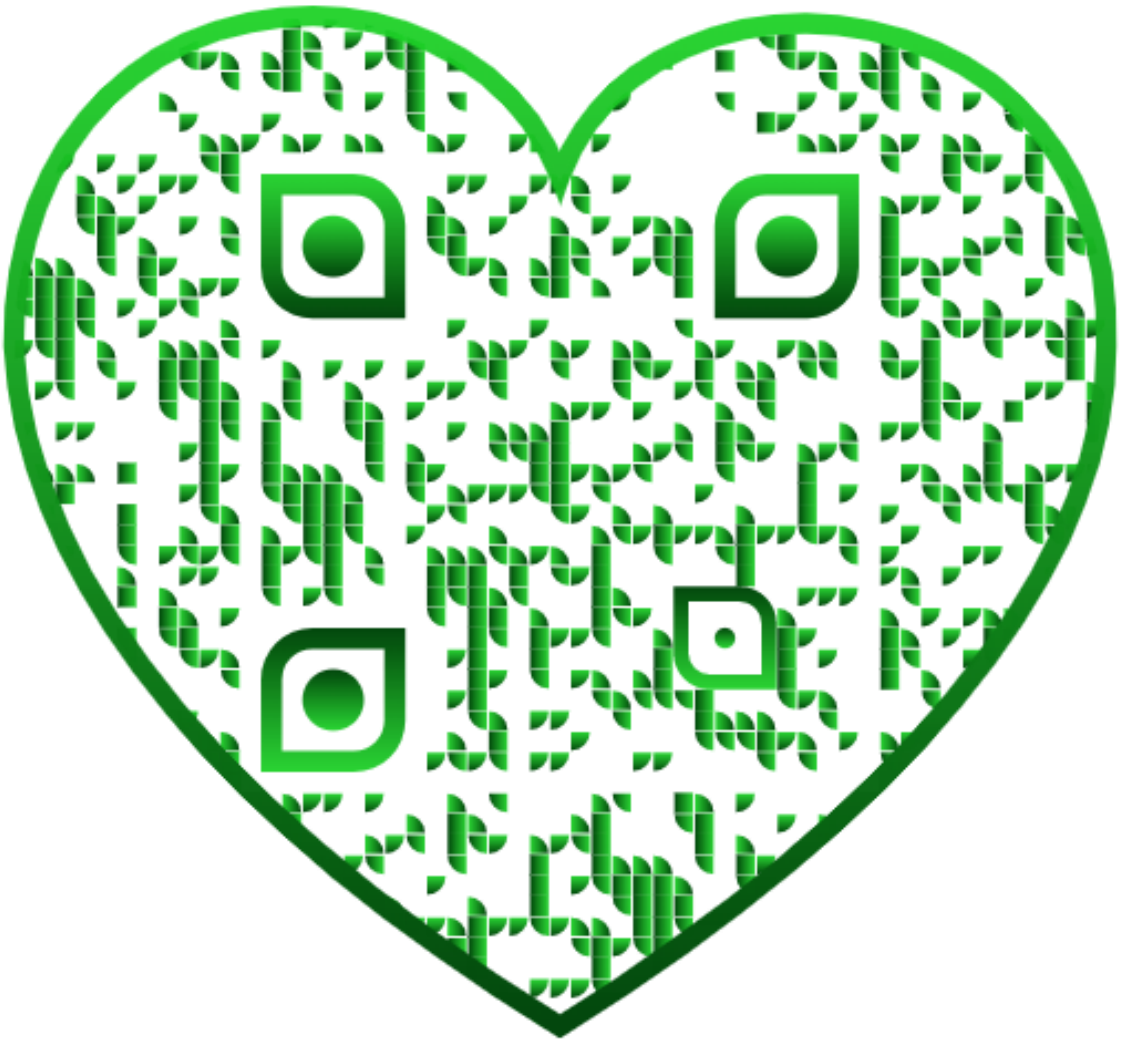

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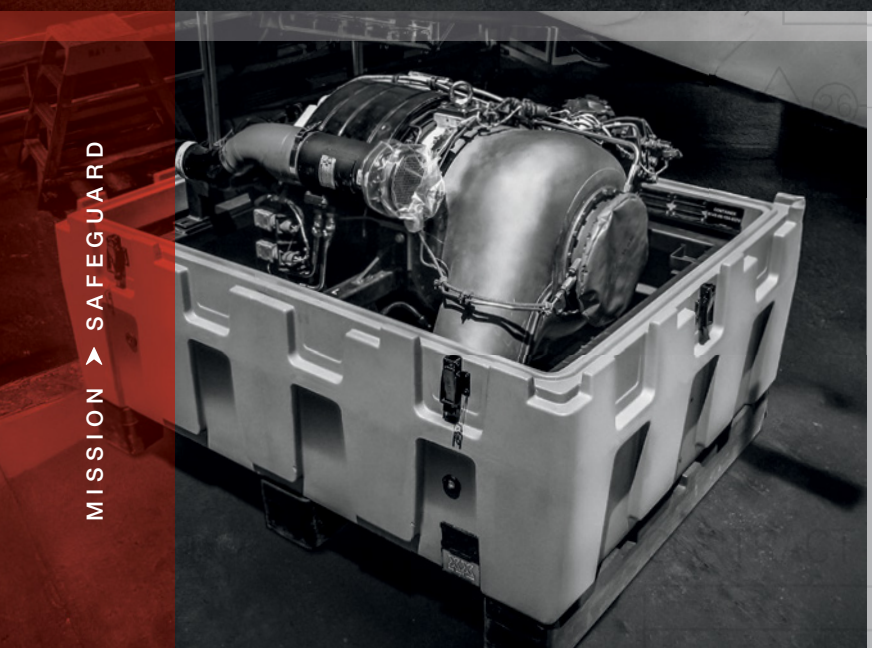

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ON THE COVER

Aitech recently launched IQSat, an artificial intelligence-enabled picosatellite. The company's goal with IQSat is to provide space-based AI processing and algorithms for a wide variety of industry verticals and applications. Some of the applications it could support include pattern of life recognition, surveillance or real-time tracking of adversaries. To learn how Aitech is bringing COTS-based computing to space with IQSat, read the feature article on page 4.
(Image: Adobe Stock)

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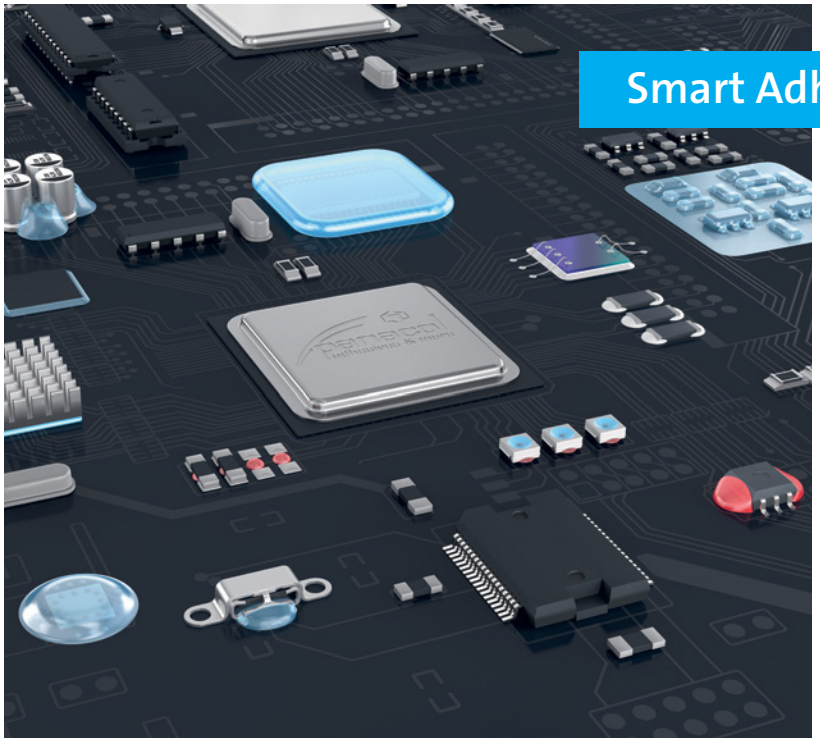
Adhesive Systems



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INSIDE STORY

Mercury Systems is a technology company that delivers mission-critical processing power to the edge. Combining technologies and expertise developed for more than 40 years, the Mercury Processing Platform offers customers a unique advantage to unleash breakthrough capabilities, enabling customers to turn data into decisions with standard products and custom integrated solutions. Signal products include DRFM subsystems and radar environment simulators. In this interview, Michael Goff, Senior Principal Scientist at Mercury Systems, discusses synthetic aperture radar, testing methods, and new simulation technology.

***Aerospace & Defense Technology (A&DT):* What are the advantages of using Synthetic Aperture Radar (SAR) over other imaging options, such as optical or LIDAR?**

Michael Goff: Synthetic Aperture Radar (SAR) systems offer several advantages over optical and Light Detection and Ranging (LIDAR) imaging systems. SAR uses radio frequency signals, enabling it to penetrate clouds and image the ground from tens of miles away, regardless of time of day or weather conditions. Additionally, depending on the signal polarization, SAR can penetrate foliage and some ground coverings, including vegetation, snow, and soil. These capabilities set SAR apart from optical imaging systems, which require clear skies, sunlight, and a line of sight to the ground patch being imaged.

On the other hand, LIDAR sensors can also penetrate cloud cover and, in some cases, water, forming images at great distances. However, LIDAR struggles with creating large images at significant angles (squinted angles) due to the challenges in maintaining phase coherency across phased array elements. SAR systems handle this effectively, allowing imaging at substantial distances and wide squinted angles, making them highly versatile. This capability enables SAR systems to operate without requiring the platform to image directly overhead.

***A&DT:* How are SAR platforms currently tested?**

Goff: Currently, SAR platform testing is heavily constrained by the limitations of laboratory setups. Typical methods include using a fiber optic delay line or radiating signals through a window, which yield low-fidelity images. These approaches significantly limit the ability to verify essential parameters such as mode operation, image resolution, registration, and sidelobe performance. Advanced capabilities, including Automatic Target Recognition (ATR) or effects such as layover, are nearly impossible to evaluate under such testing conditions. As a result, the only practical way to test SAR platforms is through actual flight scenarios, which are both logistically complicated and extremely costly.

***A&DT:* What has prohibited the development of a SAR simulator?**

Goff: Developing a comprehensive SAR simulator has been historically prohibited by the computational demands of processing ground return modulated signals in near real-time. The data processing speeds and capabilities required for such tasks only became feasible within the past six years due to advances in processing technology. These advancements have now made it possible to develop simulators capable of producing realistic ground return signals for SAR systems.

***A&DT:* What aspects of SAR imaging can the current ARES-SAR simulator test?**

Goff: The ARES-SAR simulator provides SAR systems with realistic ground return modulated signals, enabling processors to form high-resolution images on the cockpit display as if the system were in-flight during a live scenario. Beyond simulating ground returns, the ARES-SAR simulator can also insert Radar Cross Section (RCS) target models into the signal. This allows for testing and validation of post-processing capabilities, including Automatic Target Recognition (ATR).

The simulator is configurable with dual channels, one dedicated to testing SAR mapping functionality and the other introducing a radial moving target. This dual-channel setup enables basic testing of Ground Moving Target Indicator (GMTI) modes, significantly broadening the simulator's scope of application in SAR performance evaluation.

***A&DT:* How does the simulator interface with the system under test (SUT)?**

Goff: The ARES-SAR simulator integrates with the System Under Test (SUT) using Direct Radio Frequency Modulation (DRFM) technology. It supports two interfacing methods: direct injection and free-space interaction. For direct injection, the simulator uses cables to link the RF input and output ports to the sum port of the SUT. For free-space interaction, the SUT transmits and receives through its antenna, while the simulator interacts via a horn antenna, often mounted to a chamber's magic wall that dynamically moves with the simulated scenario.

Scenario setup and control are managed through the ARES-SAR server, which operates intuitive simulation software featuring a user-friendly Graphical User Interface (GUI) and real-time application tools. The software includes scenario management capabilities, parameter customization, and real-time reporting for system status, calibration, and IBIT (Initiated Built-In-Test). Additionally, the runtime window provides a visual of the imaged scene and the SUT's flight trajectory using Digital Terrain Elevation Data (DTED). During simulations, the system dynamically calculates signal attenuation based on scenario trajectory and signal power, ensuring optimal performance and accuracy throughout testing.

For more information, visit Mercury Systems at **mrcy.com/ares.**

IQSat: Aitech's AI-Enabled Picosatellite for Earth Observation and Imaging Applications

Aitech introduced its new artificial intelligence (AI)-enabled picosatellite constellation platform, IQSat, at the 40th annual Space Symposium in April. The platform is designed to bring ready to use commercial off the shelf (COTS) embedded computing to data heavy earth imaging and pattern recognition applications enabled by AI and machine learning (ML) processing and algorithms performed onboard a constellation of IQSats.

Available as an individual platform or in constellations that could include thousands of picosatellites, IQSat will become available to customers in the fourth quarter of 2025.

A unique capability of IQSat is how it leverages a software developed by Pennsylvania-based data analytics provider Intuidex called "Watchman for Space." Intuidex describes Watchman for Space as a "space data as a service" application that uses "High-Order Low-Resource Learning (HO-LRL) algorithms to provide intelligence, surveillance and reconnaissance (ISR) and space-domain awareness via pattern of life and anomaly detection."

Intuidex's pattern of life and anomaly detection algorithms — when featured within a fleet of picosatellites, such as IQSat — can give users both real time situational awareness or

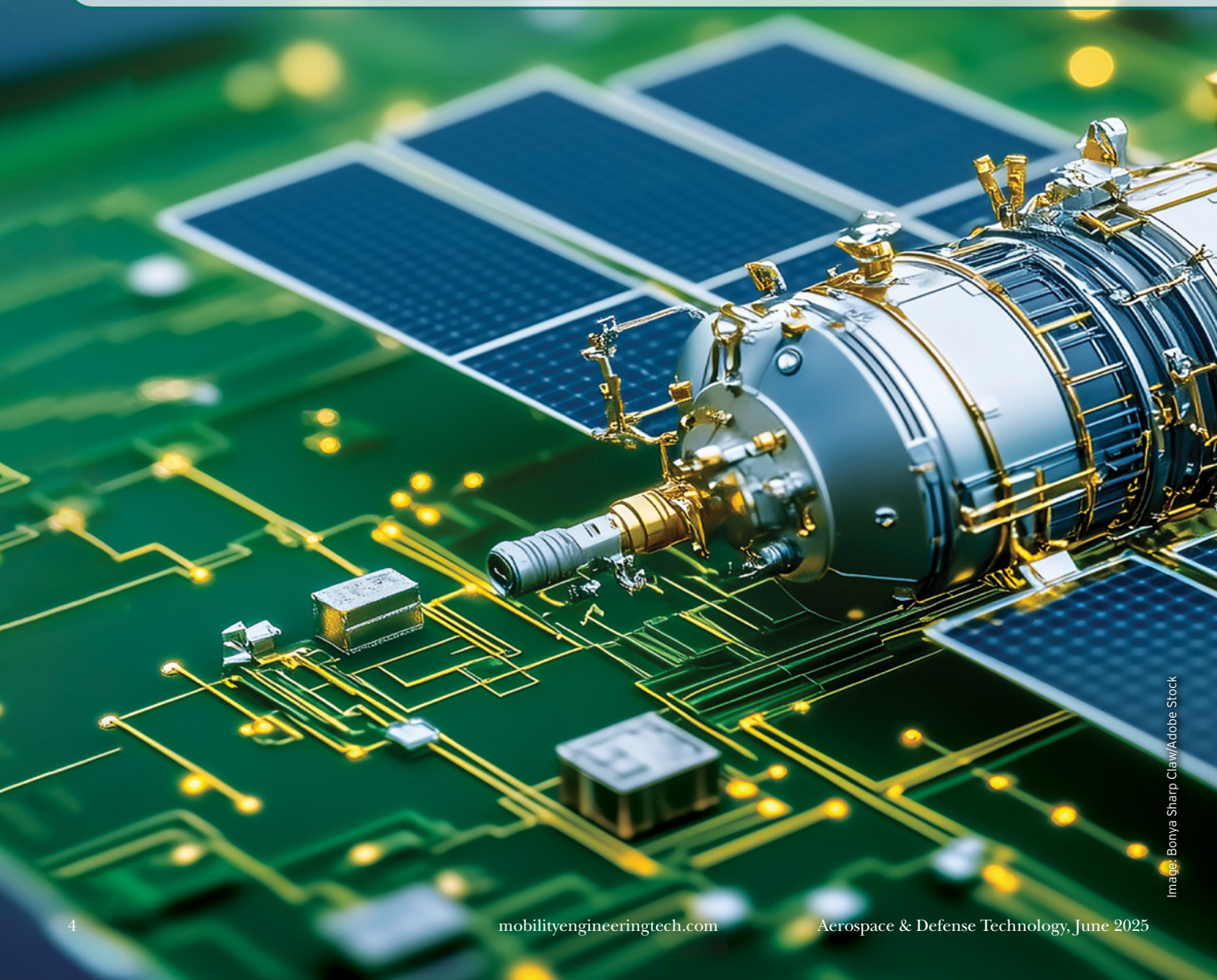


Image: Bonya Sharp Claw/Adobe Stock

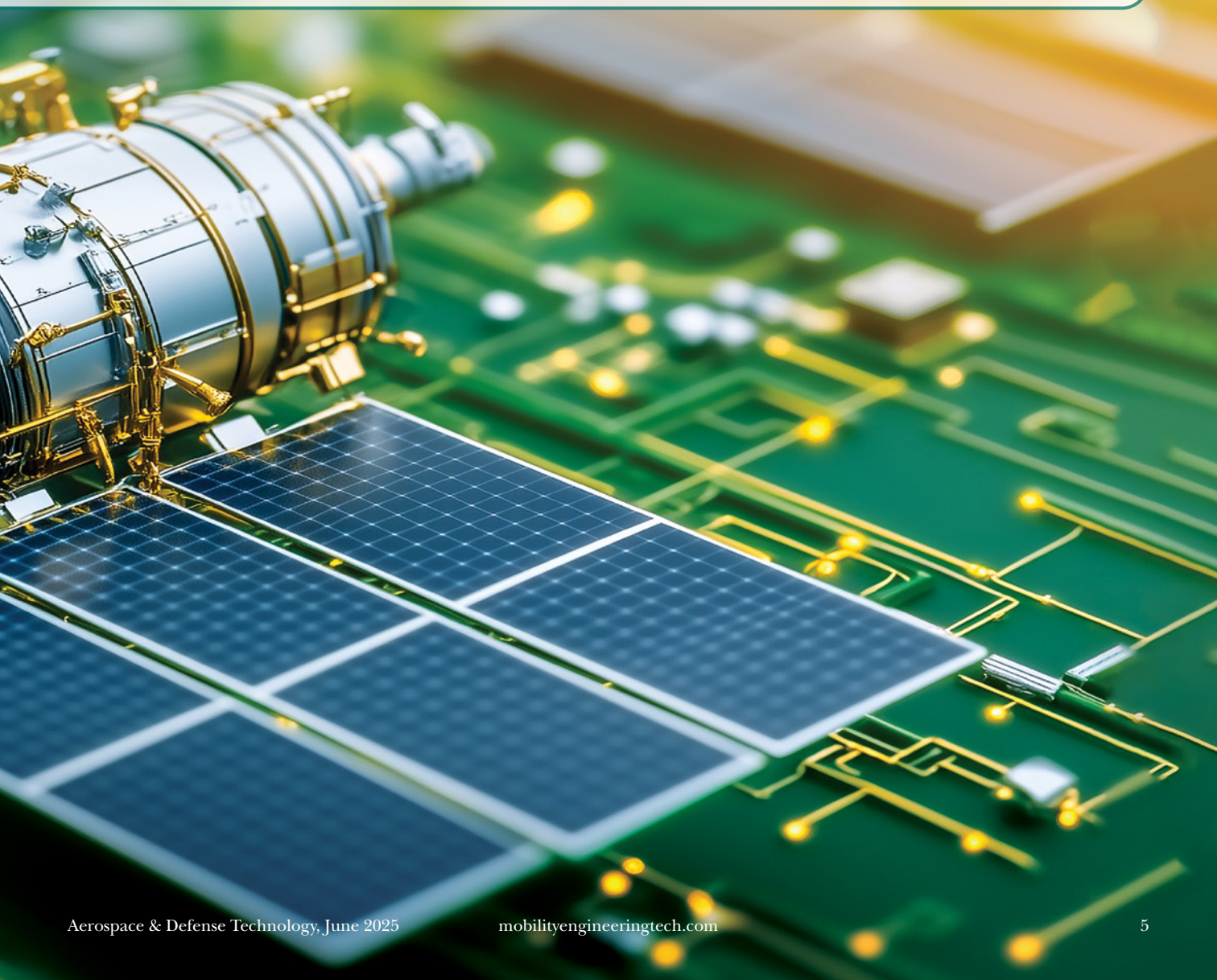
early warning and detection surveillance. Aitech further notes that the Watchman for Space software supports "rapid do-it-yourself user-based modeling, detection and tracking." Working with Aitech, picosatellite customers can use Watchman for Space to determine what type of surveillance or detection their IQSat fleet will be performing. Those parameters can be adjusted while the fleet is in-orbit, according to Intuidex's website.

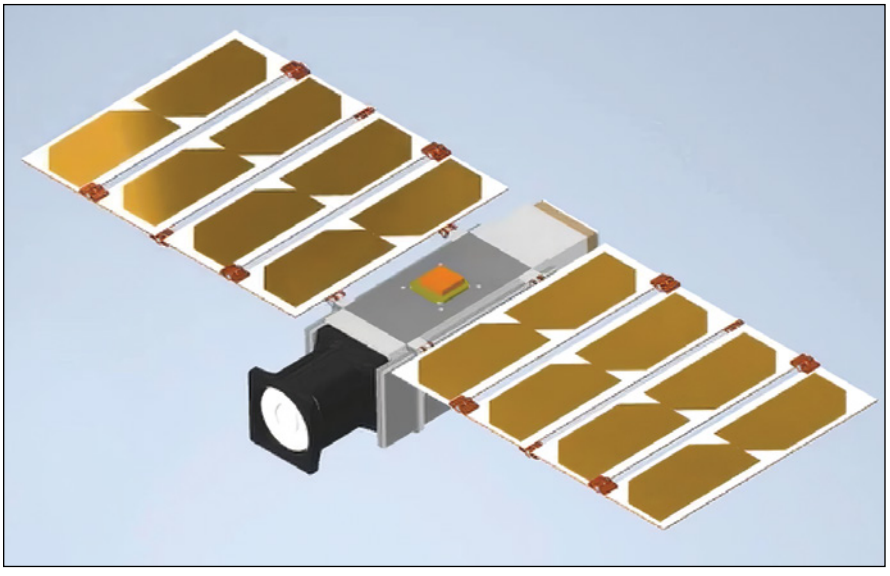
Intuidex also has previous experience providing this capability for picosatellites. In a January 2022 press release, the company describes the use of Watchman by a small satellite startup based in Lancaster, Pennsylvania, Quub. The startup featured Watchman on its own low-cost picosatellite that saw its first launch on a SpaceX Falcon 9 Transporter 3 mission from Cape Canaveral Air Force Station, Florida on Jan. 13, 2022.

"Our technology processes and fuses multiple-source sensor data and quickly identifies objects and events with high accuracy, even in situations where limited data is available for making decisions," Intuidex notes in the Quub launch press release. "This is all edge-based processing on-board the picosats, meaning the object and event detection, fusion and alerting is performed entirely onboard the picosat in milliseconds, resulting in actionable alerts in down-linked systems in near-real-time."

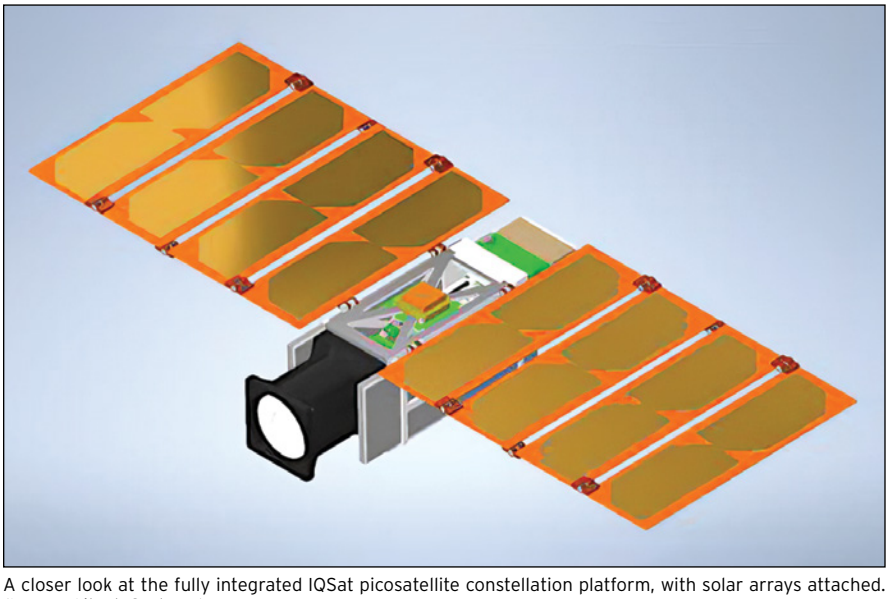
In launching their new IQSat platform, Aitech is leveraging its multi-decade track record of supplying embedded computing modules and avionics systems to a wide variety of satellites and spacecraft. Their history of supplying embedded computing for spacecraft includes the following selection from a list provided by Aitech:

- **Orbital Express:** In July 2007, two Orbital Express satellites, were launched and then operated as a demonstration by the U.S. Defense Advanced Research Projects Agency to evaluate the feasibility of on-orbit satellite servicing. Aitech provided the avionics and robotics controls for the satellites.
- **Cassiope Satellite:** In September 2013, the first Cassiope satellite was launched and operated by NASA as a "digital courier service" to provide large scale data transfers to remote commercial and military clients.





The image of IQSat released by Aitech upon the introduction of the new picosatellite platform at the Space Symposium in April. (Image: Aitech Systems)



A closer look at the fully integrated IQSat picosatellite constellation platform, with solar arrays attached. (Image: Aitech Systems)

Aitech provided the Command and Data Handling (C&DH) processor for the satellite.

- **VSS Unity:** In December 2018, Virgin Galactic performed the first suborbital space flight of its VSS Unity space plane. Aitech supplied the rocket motor controller.
- **IM-2 Lunar Lander**: On Feb. 27, 2025, Intuitive Machines confirmed the successful launch and commission into space of its IM-2 lunar lander spacecraft on its mission to the Moon. Aitech provided the IM-2's space-rated single board computer, radiation tolerant communications PMC board, and a rugged space-rated SpaceWire card. The company also provided the complete conduction-cooled hardware for the Nova-C avionics system for use as both a payload controller and image data processor on the IM-2.

These are examples from four space missions that Aitech provided embedded computing for, from a list of more than 20 satellite and spacecraft launches and operations dating back to 1997. Based on their experience providing these space-ready embedded computing building blocks for satellites and spacecraft, IQSat integrates those building blocks into one COTS-constructed flight-ready platform.

In February, NASA published the 461-page "Small Spacecraft Technology State of The Art 2024" report. The report is updated annually to analyze new information about "state-of-the-art" small spacecraft systems and design considerations for identifying components and available technologies that could help develop new satellites and spacecraft. Within the report, NASA features an overview of categorizations of small satellites and the status of small satellite and spacecraft avionics that helps provide more understanding of why IQSat is an innovative new approach to picosatellites.

NASA defines picosatellites as one of three small satellite categories — the other two being microsatellites and nano satellites. Picosatellites, according to the report, have a mass of 1 - 0.01 kg. "Since 2023 there has been an influx of constellations of mini-class small spacecraft with a mass of 201 – 600 kg, as well as a new generation of larger small spacecraft constellations weighing 600 – 1,200 kg," the report says.

NASA's report also explains how small spacecraft avionics mainly consist of the following four components: Command and Data Handling (C&DH) computer, flight software (FSW), payload and subsystem avionics.

"The C&DH and FSW are the brain and nervous system of the integrated avionics system, and generally provide command, control, communication, and data management interfaces with all other subsystems in some manner, whether in a direct point-to-point, distributed, integrated, or hybrid computing mode," the report says.

There is also an interesting excerpt from NASA's report that explains the type of COTS-based spacecraft embedded computing trend that can be

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observed in platforms like IQSat. The report notes increasing demand for commercial, military and research missions that fly "data-heavy payloads" and a "new interest in advanced onboard processing for mission data."

"Next-generation SSA/PSA distributed avionics applications are integrating FPGA-based software-defined radios (SDR) on small spacecraft. A SDR can transmit and receive in widely different radio protocols based on a modifiable, reconfigurable architecture, and is a flexible technology that can enable the design of an adaptive communications system," NASA's report says. "This can increase data throughput and enable software updates on-orbit, also known as reprogrammability. Additional FPGA-based functional elements include imagers, artificial intelligence and machine learning processors, and subsystem-integrated edge and cloud processors."

A different image of IQSat provided by Aitech within the new product brochure for the new picosatellite constellation platform. (Image: Aitech Systems)

IQSat's COTS-Based Design

During an interview with *Aerospace & Defense Technology* ahead of the launch of IQSat, Pratish Shah, Aitech's U.S. General Manager, explained how IQSat has flexible payload options that consume up to 30 watts of continuous power in sunlight. Each IQSat has an operational life of up to three years. The picosatellite constellation platform is radiation tolerant for Low Earth Orbit (LEO) and Near Earth Orbit (NEO) operations, and has communications options that include S-Band, JADC2, and ISL/STG.

"Space-based infrastructure solves big problems and fuels big advancements on Earth. The new IQSat platform is integral to space accessibility by delivering low cost, rapid deployment constellations that provide access to actionable information quickly and frequently for infinite applications," Shah said. "Whether used for military and defense, environmental or agricultural applications, communications or scientific research, the flexibility, cost and availability of a solution like IQSat has not existed before – providing more accessibility to the power of space."

Shah also explained how the cost of down-linking data from satellites today can be prohibitively expensive for commercial organizations, research firms and government agencies. Instead of sending raw data from space like most satellites do today, IQSat's onboard AI and ML processing and algorithms can be programmed to downlink only the information or data needed by the end user.

As Aitech notes in its press release launching the new platform, "IQSat offers the industry's first common payload interface designed to host multiple payloads on a single flexible electrical and mechanical interface, allowing for quick and standardized designs to reduce cost, NRE and time to launch."

A PowerPoint presentation explaining IQSat's architecture depicts the picosatellite platform's design featuring a small rectangular structure that contains three separate modules. These modules include a small propulsion and attitude control module on one end. That module is connected to a slightly larger avionics module that contains the AI-enabled flight processor, communications, electrical power system and a standardized mechanical and electrical ICD/bus. The third smaller module connected to the avionics module on the other end is the payload module where cameras, sensors and other devices can be customized by end users. Aitech describes this payload module as the "functional end that enables limitless applications."

A 13-second animation of IQSat's assembly created by Aitech shows a small rectangular structure effectively serving as the chassis or enclosure for the three modules, where small embedded computing components such as printed circuit boards, memory and processing are stacked and aligned with the payload module at the front-facing end of the picosatellite. Each fully integrated IQSat also includes a solar array, antenna and wiring. Aitech has a fully functional prototype being tested and evaluated at their headquarters in California that shows how the onboard AI and ML processing is enabled.

"We want to provide customers for earth observation, pattern recognition and other space-based applications access to COTS-based AI processing occurring onboard the picosatellite," Shah said. "IQSat provides this COTS approach for customers, without requiring the need for a deep knowledge of satellites or operating in space, because the platform has already taken care of that."

This article was written by Woodrow Bellamy III, Senior Editor, SAE Media Group (New York, NY).

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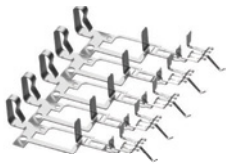

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Pushing the Boundaries of Rapid Production of Spacecraft: Flight Results from NearSpace Launch's TROOP and ThinSat Platforms

NearSpace Launch Inc. (NSL), a privately held and fully U.S.-owned aerospace company, is actively redefining the boundaries of responsive spaceflight through its development and deployment of the Train Rapid on Orbit Payload (TROOP) and ThinSat platforms. Over the past decade, NSL has launched more than 100 small satellites and over 900 flight systems and subsystems into orbit. NSL's satellites have been part of launches operated by Astra, Atlas, Delta, Firefly Aerospace, Northrop Grumman, Virgin Galactic and SpaceX among others.

Headquartered in Upland, Indiana, NSL is currently the largest small satellite manufacturer in the midwestern region of the U.S., uniquely positioned to address urgent national needs for rapid space access and technology testing.

The company's co-founders, Dr. Henry (Hank) Voss and Jeff Dailey, bring more than 70 years of combined expertise in satellite development, space weather instrumentation, and aerospace systems engineering. NSL gained its roots from Taylor University, where it helped launch Indiana's first satellite, TSAT.

NSL's engineering approach to designing and manufacturing satellites and satellite subsystems is rooted in simplicity, efficiency, iteration, and mission reliability. The company's hybrid integrated development process enables it to deliver complete satellite systems in just six to nine months far shorter than the traditional multi-year process seen across the aerospace industry. This rapid turnaround is achieved through in-house manufacturing of core subsystems, including satellite buses, communications payloads, and power systems. This vertical integration not only accelerates production but also strengthens supply chain resilience and quality control, ensuring that components are tailored to mission-specific requirements.

Rather than adopting a rigid model-based systems engineering (MBSE) framework, NSL incorporates practical MBSE elements selectively to support streamlined design, testing, and iteration. Leveraging the use of MBSE is especially significant today, as the Department of Defense and other U.S. government agencies are transitioning to the use of digital

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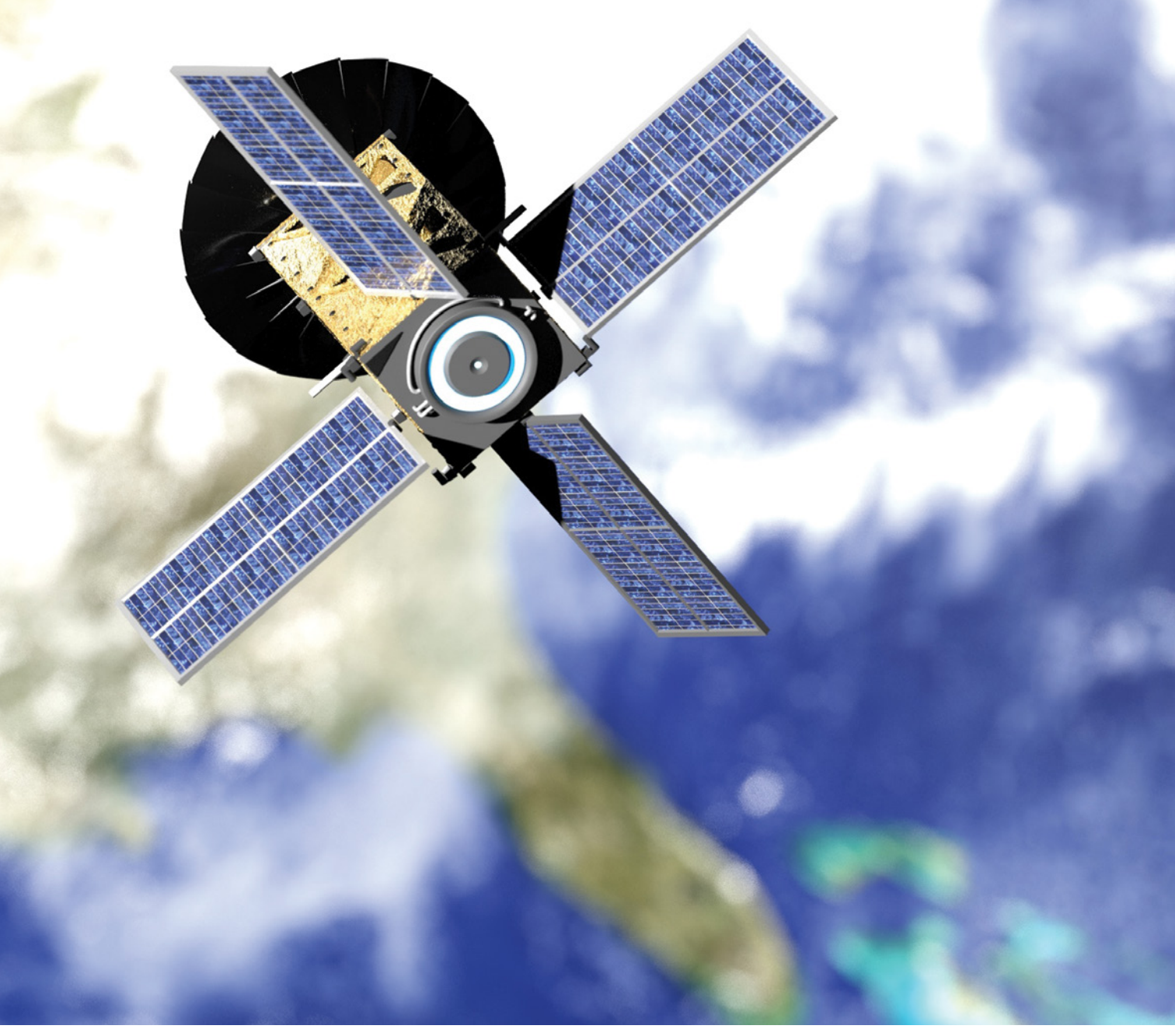


engineering and model-based approaches to acquisitions of new satellites and subsystems, and away from the paper-based manual structures that have guided their acquisition process for decades.

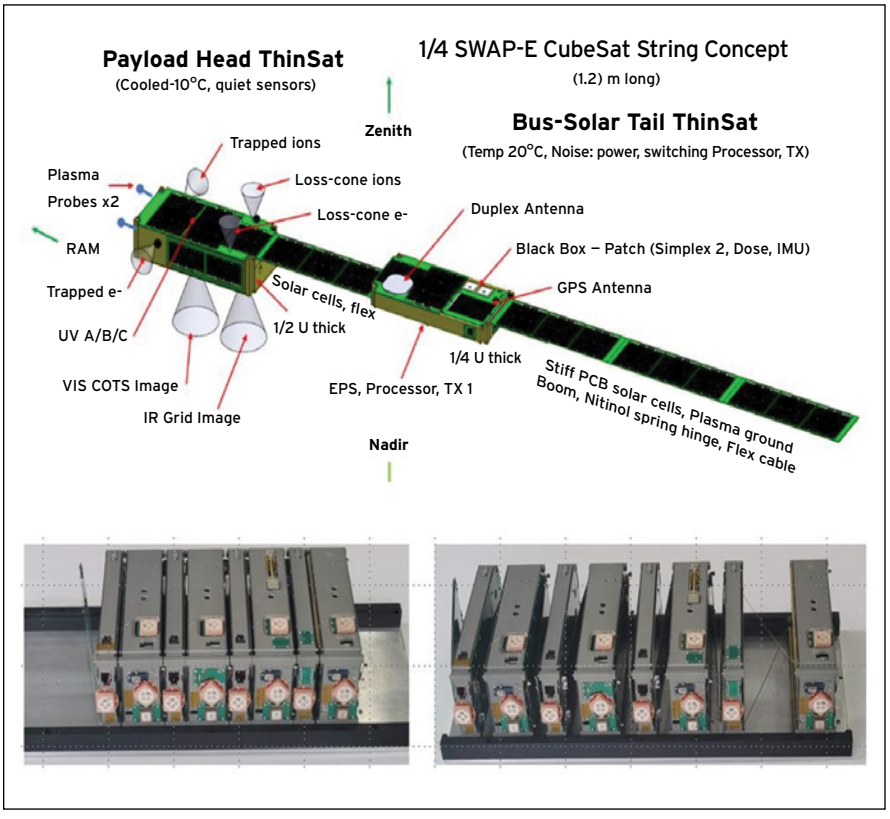
NSL's pragmatic approach to MBSE emphasizes flexibility and responsiveness to customer needs, aligning well with government programs that demand rapid development cycles and real-world adaptability. This philosophy is especially evident in NSL's platform architecture, where simplicity in design directly translates to reduced failure modes and improved in-orbit performance.

The TROOP platform represents a flagship example of NSL's innovation in hosted payload services. TROOP enables the integration of multiple customer payloads aboard a standardized small satellite bus, dramatically lowering the cost and complexity of on-orbit experimentation. Each mission under the TROOP banner includes end-to-end services — payload integration, licensing, regulatory coordination, launch, and operations — offered as a bundled solution. The most recent mission, TROOP-F2, launched aboard a SpaceX vehicle in August 2024, further demonstrates the maturity and versatility of the platform.

TROOP-F2 is a 6U free-flyer that incorporates several key technologies developed and tested by NSL. The satellite hosts three EyeStar S4 transceivers with distinct antenna and pointing configurations to evaluate performance across varied link geometries. It also includes a suite of advanced space weather sensors developed in partnership with NASA, under the Space Weather Array Prompt Experiment (SWAP-E) initiative.

These instruments include low- and medium-energy particle detectors, a total integral dose radiation sensor, and a plasma probe, all optimized for low-power and compact form factors. In addition to these science payloads, TROOP-F2 also carries multiple next-generation NSL-developed bus systems, including the GPS unit, a new attitude determination and control system (ADCS), enhanced power electronics, rad-hardened solar cells, and advanced onboard processors.

Payloads onboard TROOP missions are integrated using a standardized interface control document (ICD) and

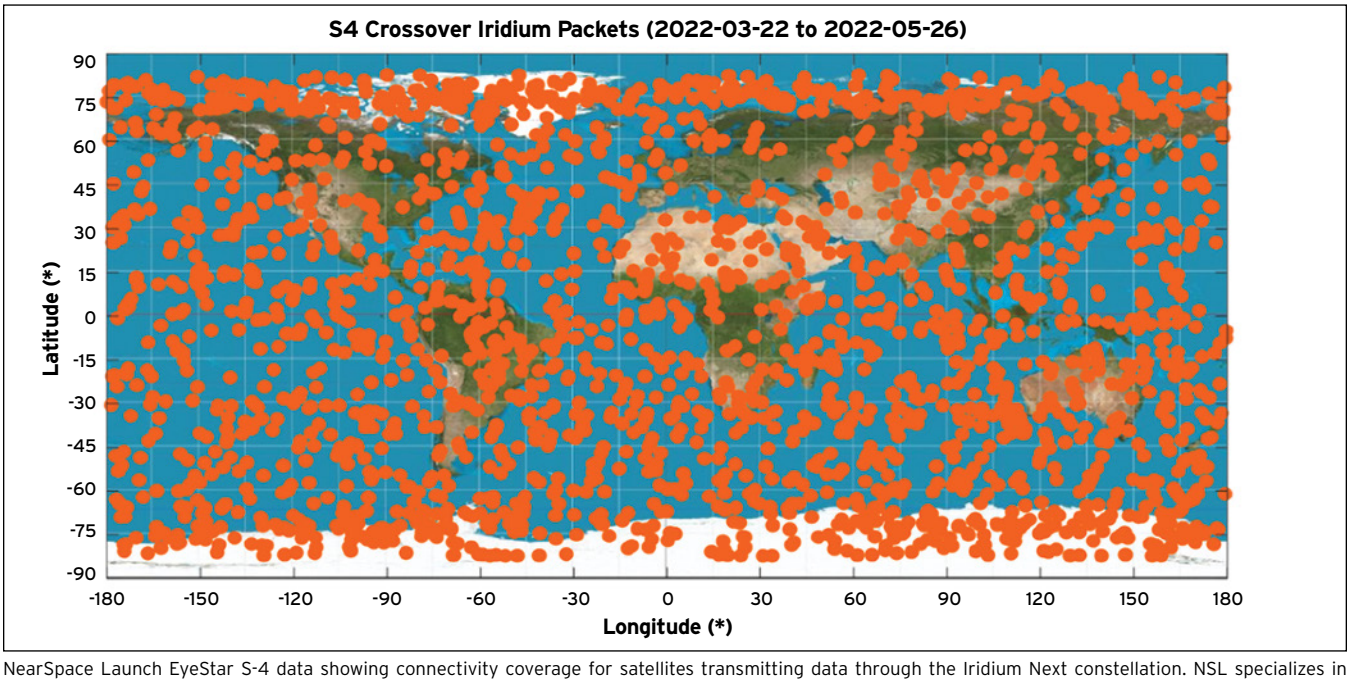


Top: An overview of the individual components and systems featured on NSL's ThinSats. Bottom: NSL's ThinSats come in different shapes and sizes, as shown here. (Image: NSL)

a TTL or RS422 Serial UART emulator, allowing for plug-and-play compatibility and rapid turnaround. Each payload is assigned dedicated access to shared bus resources in a time-sharing model, with hardware isolation to prevent fault propagation. This configuration allows multiple customers to conduct independent experiments aboard the same spacecraft, while still meeting data security and operational integrity requirements.

In addition to TROOP, NSL's ThinSat program is expanding the design envelope for compact, modular satellite architectures. ThinSats are ultra-thin spacecraft, typically ranging from 1/7U to ½U in volume, offering significant advantages in packing density, aerodynamics, and radiation shielding. The design of NSL's ThinSats was inspired by several factors, including helping to lower the cost of using satellites for education and research at colleges and universities throughout the U.S.

Moreover, ThinSats were developed in response to the need for lower-cost satellites and constellations with miniaturized sensors for high performance (ease of assembly, maximize solar array surface area for power, aerodynamic for lower drag or for deorbit, ease of testing, robotic assembly, improved thermal, high radar



NearSpace Launch EyeStar S-4 data showing connectivity coverage for satellites transmitting data through the Iridium Next constellation. NSL specializes in uninterrupted global satellite communication hardware by leveraging existing commercial satellite-to-satellite networks. (Image: NearSpace Launch)

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cross-section, and new paradigms of string interconnections). NSL's creation of the 5 cm on a side PocketQube and implementation of the ThinSat concept were used to inspire STEM education, to drastically reduce student satellite cost, launch cost to space and cycle time to orbit (launch every 6 months). These platforms can be flown individually or linked in multi-unit "strings" to share power, data, and redundancy. The ThinSat form factor supports modular mission profiles and allows for robotic assembly, enabling faster production and configuration for a wide variety of use cases.

A common element in both the TROOP-F2 and RAPSat-1 missions is the deployment of NSL's new low-SWaP-C (Size, Weight, Power, and Cost) ADCS. This system relies exclusively on magnetorquers for actuation and supports a range of pointing modes including magnetic, solar, nadir, and velocity vector alignment. Designed to operate with minimal input from onboard computers, GPS, or ground stations, the ADCS supports autonomous spacecraft operation with highly efficient command and telemetry protocols. This low-bandwidth approach enables reliable attitude control even in constrained communication environments.

Communication reliability is a cornerstone of NSL's operational infrastructure. To date, the company has achieved a 100 percent success rate for all flight-verified S3 and S4 radio systems. These communication subsystems provide robust telemetry downlinks and command uplinks, and are fully integrated into NSL's secure mission operations console. This web-based platform allows customers to access real-time data, monitor incoming packets, issue commands, and receive alerts from both desktop and mobile devices — supporting responsive mission oversight and operational flexibility.

Through its development of the TROOP and ThinSat platforms, NSL is directly supporting the evolving requirements of defense, civil, and commercial space customers. By offering rapid, reliable, and affordable access to space for technology demonstration, environmental sensing, and communications testing, NSL is playing a critical role in modernizing space capabilities for the United States and its partners. The developments made through the launch of TROOP-F2 and RAPSat-1 illustrates the value of NSL's engineering philosophy and integrated manufacturing strategy in enabling fast-paced innovation and national space resilience.

This article was written by Dr. Henry (Hank) Voss and Jeff Dailey, Matt Voss, and Jasmin Consales for Near Space Launch (Upland, IN). **For more information, visit www.nearspacelaunch.com**

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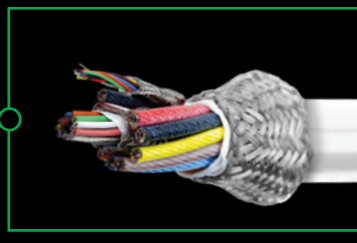

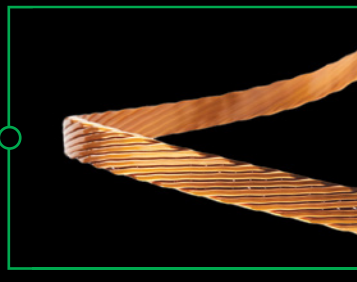

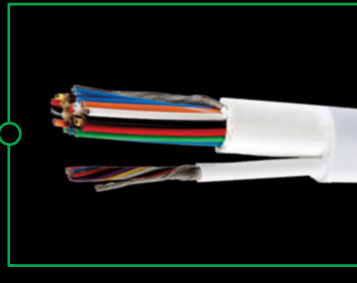

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Transforming Satellite Antenna Technology for the Next Era of Aerospace and Defense

The global satellite communications (SATCOM) sector is undergoing profound transformation. Fueled by the rapid growth of low Earth-orbit (LEO) constellations, increased government investment, and heightened demand for secure, high-throughput connectivity, the market is projected to expand from $66.75 billion in 2025 to $103.78 billion by 2029[1, 2].

This momentum reflects a broader realignment of priorities across commercial and defense markets: a shift from reliance on legacy geostationary systems toward agile, resilient networks capable of supporting next-generation missions and applications.

The Rise of LEO Constellations and the Demand for Change

A decade ago, approximately 1,000 active satellites orbited the Earth. Today, that number approaches 10,000, the majority residing in LEO[3], and is predicted to exceed 100,000 by 2032, as shown in Figure 1. This dramatic expansion, as reported by the International Telecommunication Union (ITU), has been enabled by advances in satellite miniaturization, manufacturing, and launch technologies, creating constellations that provide persistent, low-latency global coverage [3].

The ITU emphasizes that the LEO revolution is reshaping both the economics and architecture of satellite communications, enabling a global mesh network that supports remote sensing, secure communications, and broadband services at unprecedented scale.

For aerospace and defense operators, this shift carries strategic importance. Rapid deployment and replenishment of satellites have become operational imperatives, supporting functions ranging from secure command and control to intelligence, surveillance, reconnaissance (ISR), and resilient communications in contested environments [4]. The smaller, lighter satellites and terminals demanded by these missions are not just more economical; they are vital for operational flexibility and mission success.

Why Traditional Antenna Solutions Fall Short

Despite significant progress in satellite bus design and launch capabilities, antenna technology has emerged as a bottleneck for next-generation systems. Traditional flat panel phased array antennas, typically built on silicon and printed circuit board (PCB) substrates, face challenges in scaling to higher frequencies and larger apertures without significant penalties in size, weight, power, and cost (SWaP-C)[5, 6].

In many modern satellite platforms, antennas account for up to 20 percent of total payload mass, directly impacting launch costs and constraining the ability to integrate additional sensors or extend mission lifetimes[4].

Aerospace and defense stakeholders recognize this issue. Phased array antennas are now becoming essential for the type of performance required to enable next-generation radar and communications applications, offering advantages such as rapid elec-

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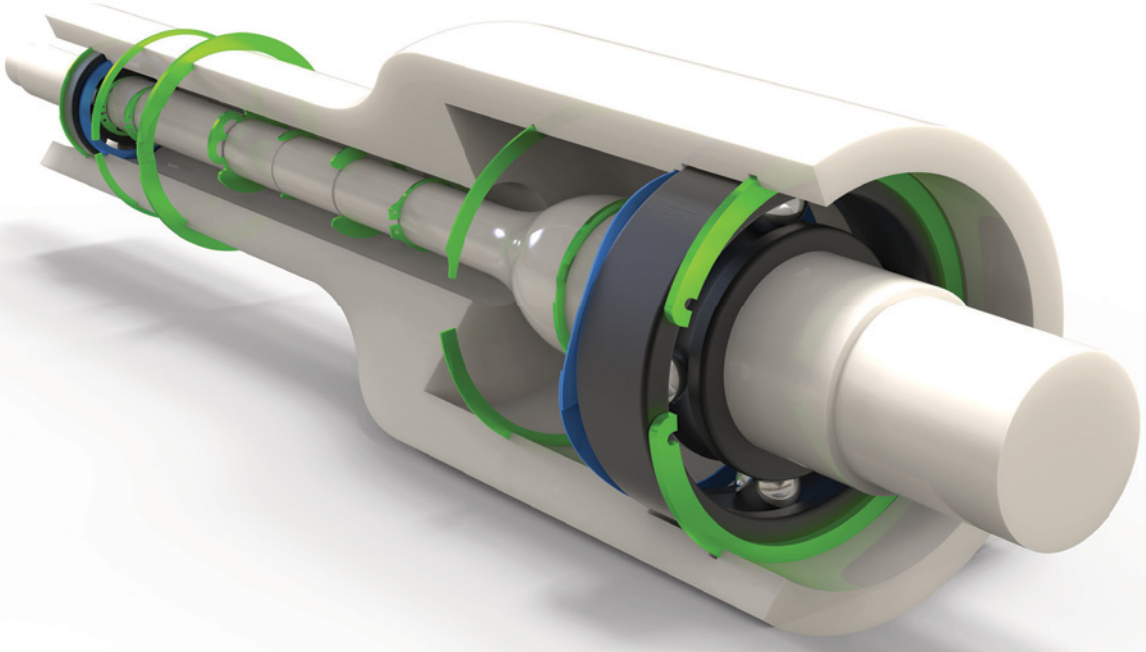

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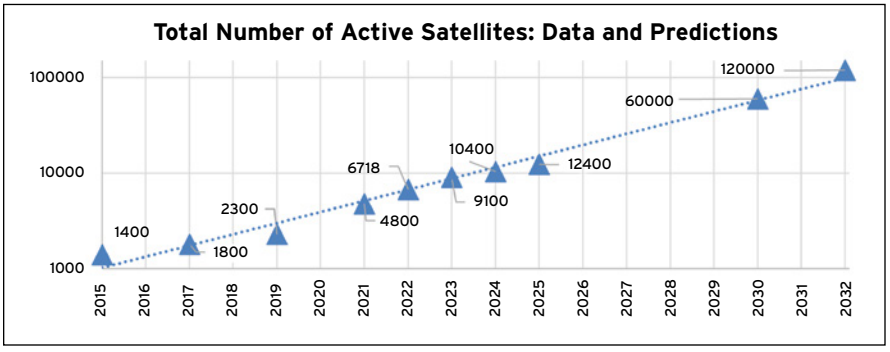

Figure 1. According to an analysis by Circuits Integrated Hellas based on data from the ITU, the UCS Satellite Database, and various market reports, the number of active satellites has grown nearly tenfold over the past decade, driven primarily by the deployment of LEO constellations. (Image: ITU)

tronic beam steering, multi-beam operation, and resilience to jamming and electronic countermeasures. However, improvements in SWaP-C remain critical to unlocking the full potential of these technologies.

Kythrion: A Platform Engineered for the Modern Mission

To address these challenges, Circuits Integrated Hellas (CIH) has developed Kythrion, a new antenna platform that leverages 3D heterogeneous integration (see Figure 2). Founded in 2019, CIH is a startup that is attempting to bring advanced semiconductor technologies that merge III-V materials and silicon in groundbreaking 3D integrated circuit stacks to satellite communications. At the inaugural Farnborough International Space Show in February, CIH was named the winner of the "Innovation Award in Space" for their Launch Pad startup competition.

By combining III-V compound semiconductors, such as gallium arsenide (GaAs) and gallium nitride (GaN), with silicon technologies in a 3D system-in-package (SiP) / antenna-in-package (AiP) architecture, Kythrion achieves substantial performance gains. As noted in an interview with CTO of British semiconductor company IQE plc featured in the September 2024 issue of Sensor Technology, a sister publication to Aerospace & Defense Technology, the specific class of compound semiconductors known as III-V materials are those that combine two or three different chemical elements from column III and V on the periodic table. They're known for outperforming silicon in power and speed, although the key to leveraging this performance boost is to mate them with silicon. These compound semiconductors are capable of operating at higher frequencies, higher voltages and higher temperatures. They also have the ability to emit and absorb light.

CIH's proprietary chip solution heterogeneously integrates high-performance power amplifiers, phase shifters, and other critical RF components together in a compact package, thus reducing the antenna footprint required for these components by up to 78 percent compared to today's flat panel antenna configurations.

As shown in Figure 3, compared to legacy phased array modules, Kythrion delivers:

- Greater than 60 percent reductions in antenna size, weight, and cost.
- More than 15 percent improvements in power efficiency for equivalent effective isotropic radiated power (EIRP) and gain-to-noise-temperature ratio (G/T).

These enhancements enable a new generation of lightweight, agile, and scalable SATCOM terminals, suitable for both spaceborne and terrestrial applications.

The technical advantages of this approach are tightly aligned with operational needs. Kythrion's compact form factor reduces mass, freeing capacity for additional payloads or fuel reserves. Its improved efficiency reduces both power consumption and thermal load, supporting longer mission durations and more demanding operational profiles. Critically, the platform's modularity and scalability allow customization for specific mission profiles, including multi-beam tracking and software-defined networking applications.

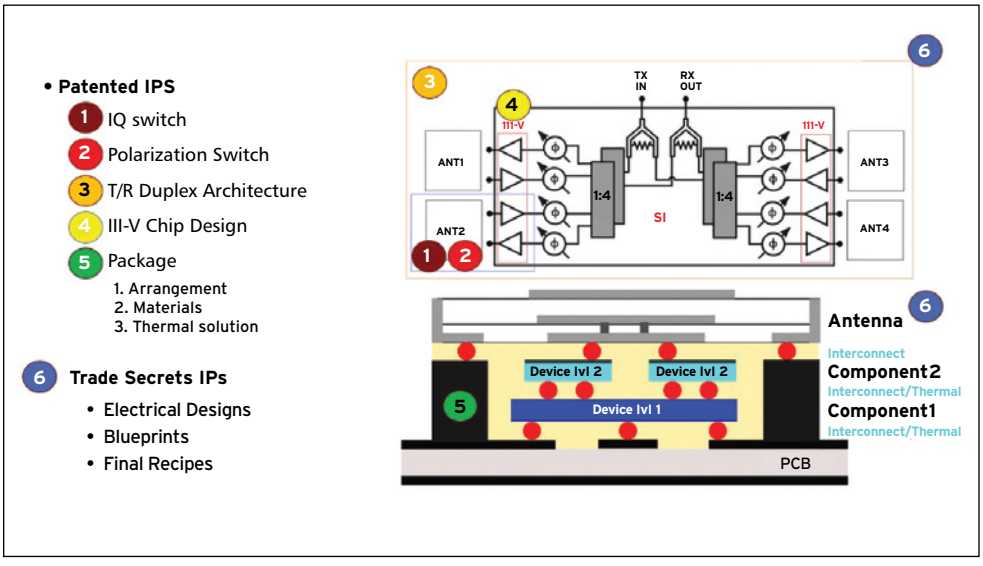

Figure 2. Kythrion 3D AIP System and Integration. (Image: CIH)

Broader Trends Shaping the Satellite Communications Industry

The drive for innovation extends beyond technical domains. Geopolitical factors

and public policy are accelerating the adoption of advanced satellite technologies. Recent analysis by The Business Research Company highlights that government investment and modernization initiatives are key drivers of SATCOM market growth, particularly around LEO constellation deployment and military communications upgrades [1, 6].

Simultaneously, the democratization of launch and satellite manufacturing, spurred by reusable rockets and new commercial entrants, has shifted cost pressures away from launch services and satellite buses, placing new emphasis on the ground segment. High-performance, cost-effective antennas are increasingly viewed as the primary lever for driving system-wide cost reductions and supporting rapid scaling.

As the global market for satellite data services is forecasted to reach $55.24 billion by 2034, demand for efficient, scalable antenna solutions is set to intensify [7].

Advanced Integration: Unlocking the Next Leap

Advanced semiconductor integration is poised to enable the next leap in SATCOM performance. Merging III-V materials and silicon in compact, high-efficiency packages offers clear advantages in power density, frequency scaling, and thermal management.

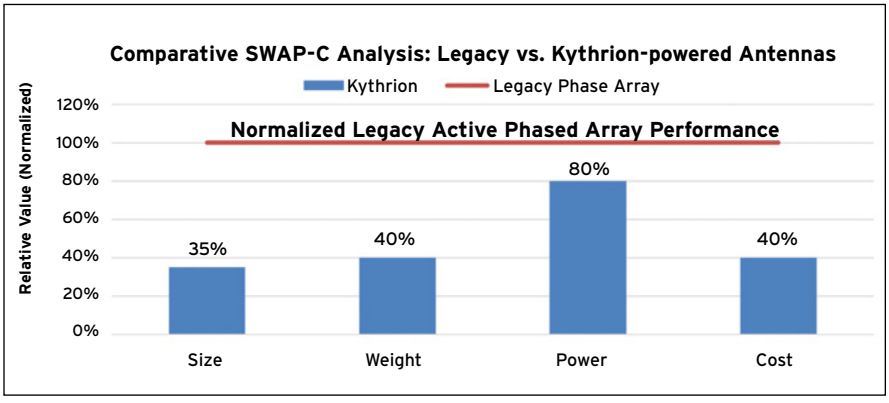

Figure 3. Comparative SWaP-C Analysis: Traditional vs. Kythrion-powered Antennas. Source: Company internal data, 2025. (Image: CIH)

Figure 4: A SpaceX satellite. (Image: CIH)

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Once a specialized technology reserved for defense radar systems, phased array antennas have become central to modern satellite communications. They offer beam agility, multi-beam capability, and electronic reconfiguration without moving parts [5, 6] — capabilities that align well with the dynamic and contested environments envisioned for future aerospace and defense missions.

The aerospace and defense satellite communications sector stands at the threshold of a generational shift. As demand accelerates for resilient, secure, and global connectivity, the limitations of traditional antenna technologies have become increasingly evident. Solutions like Kythrion, with their high degree of integration and performance optimization, are positioned to set new industry benchmarks for size, weight, cost, and capability.

References:

1 The Business Research Company. "Satellite Communication Market Report 2025.", https://www.thebusinessresearchcompany.com/report/satellite-communication-global-market-report

2 International Telecommunication Union (ITU). "Space Connect: The rise of LEO satellite constellations.", https://www.itu.int/hub/2025/02/space-connect-the-rise-of-leo-satellite-constellations/

3 DataHorizzon Research. "Phased Array Antenna Market Size, Growth, Scope & Forecast.", https://datahorizzonresearch.com/phased-array-antenna-market-20663

4 Precedence Research. "Satellite Data Services Market Size to Hit USD 55.24 Billion by 2034.", https://www.precedenceresearch.com/satellite-data-services-market

5 Mordor Intelligence. "LEO Satellite Market Size & Share Analysis - Industry Research Report.", https://www.mordorintelligence.com/industry-reports/low-earth-orbit-satellite-market

6 Allied Market Research. "Military Antenna Market Size, Trends Analysis and Forecast 2033.", https://www.alliedmarketresearch.com/military-antenna-market-A09184

7 GlobeNewswire/SNS Insider. "Satellite Communication Market to grow USD 194.55 Billion by 2032.", https://www.globenewswire.com/news-release/2025/02/24/3031235/0/en/Satellite-Communication-Market-to-grow-USD-194-55-Billion-by-2032-Driven-by-advancements-in-5G-and-low-earth-orbit-LEO-satellites-SNS-Insider.html

All statements and data are substantiated by the cited external references and reflect the latest available research and industry analysis as of April 2025.

This article was written by Paolo Fioravanti, CEO, Circuits Integrated Hellas (Kifissa, Greece). **For more information, visit www.circuitsintegrated.com.**

Legacy in Action: *The Enduring Role of MIL-STD-1553B*

For nearly 50 years, MIL-STD-1553B has quietly powered mission-critical communications across defense and aerospace platforms. Known for its unrivaled reliability and precision, this legacy standard remains essential even as next-gen systems emerge. This article explains from an RF engineer's perspective how MIL-STD-1553B continues to evolve, supporting today's advanced technologies without compromising the robustness trusted by militaries and space agencies worldwide.

MIL-STD-1553B is a time-division multiplexing (TDM) data bus standard, first adopted by the U.S. Department of Defense (DoD) in the early 1970s, and initially used on the F-16 Fighting Falcon fighter jet. It soon became a de-facto standard across military aircraft, ground vehicles, and maritime vessels and has since been adopted for platforms operated by all branches of the U.S. military, NATO, and NASA. Increasingly, it's also finding applications in commercial aerospace and industrial environments.

A Legacy of Reliability

Operating at 1 Mbps, the 1553B bus employs a dual-redundant architecture, ensuring data integrity and continuity even in the event of a failure. Its low-frequency transmission, below 500 MHz, and two signal paths — a primary and a backup — provide a critical layer of reliability. The standard supports up to 31 remote terminals, including flight control systems, mission computers, and weapons systems, enabling synchronized and secure data exchange.

One of the key technical advantages of MIL-STD-1553B is its deterministic communication protocol. Unlike Ethernet-based systems, where packet delivery times can vary, the 1553B standard guarantees message delivery within a defined time frame. This predictability is essential in applications where timing precision and low-latency response directly impact mission success.

Moreover, the system topology includes not only the remote terminals (RTs) but also a Bus Controller (BC), which manages communication over the bus, and a Bus

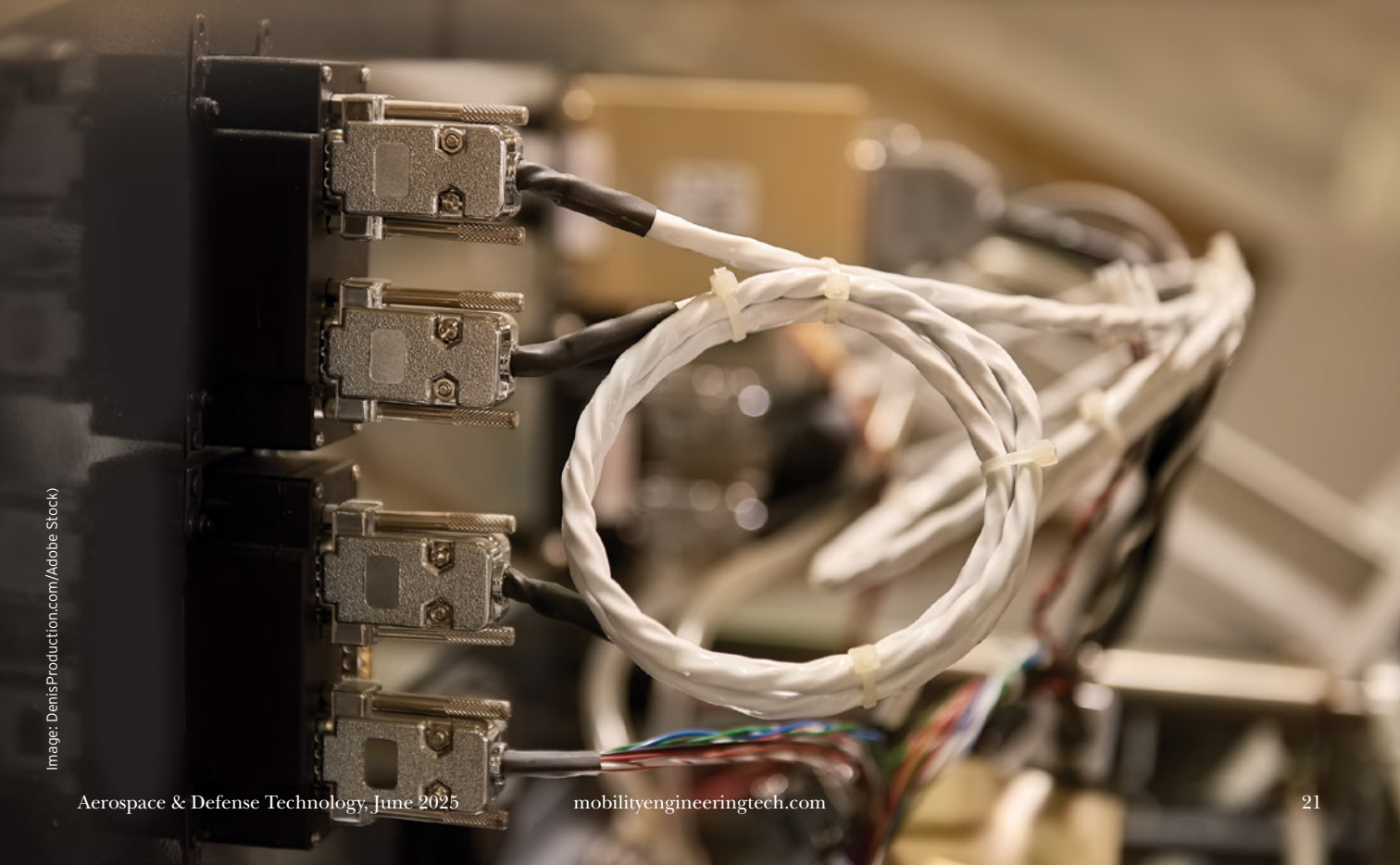


Image: DenisProduction.com/Adobe Stock)

Monitor (BM), which observes data traffic without interfering. These components ensure seamless operation and data integrity across the system.

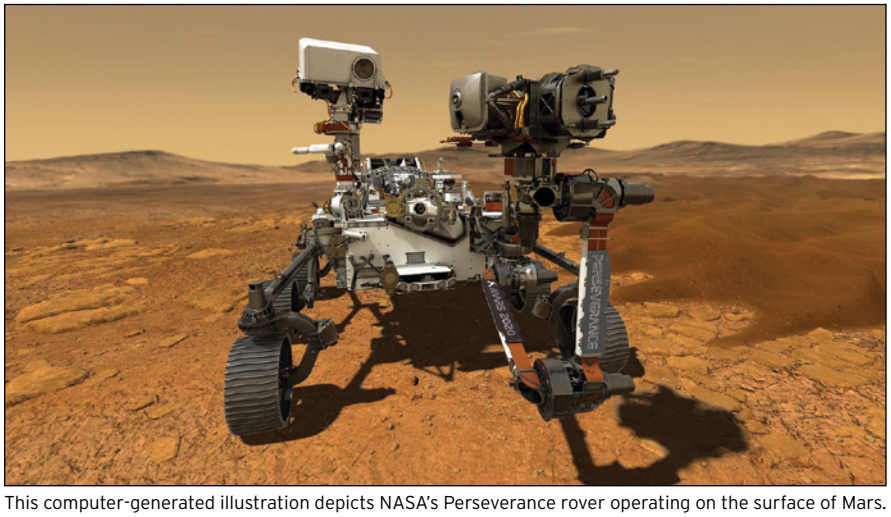
The System Controller (SC) oversees the entire system, ensuring proper coordination, while the System Monitor (SM) handles performance monitoring and diagnostics. This bus architecture is typically arranged in a daisy-chain configuration, with each terminal connected through the bus, facilitating efficient communication and data flow. The fail-safe redundancy architecture minimizes the risk of single points of failure, a critical factor in high-stakes environments.

Modern Innovations

Despite its longevity, MIL-STD-1553B has not remained static. Modern implementations incorporate enhanced physical layer components, such as advanced transformer-coupled connectors and transceivers that offer increased signal integrity and reduced electromagnetic interference (EMI).

Recent implementations include the Lockheed Martin F-35 Joint Strike Fighter, which integrates MIL-STD-1553B alongside higher-speed data protocols like IEEE 1394 and Fiber Channel. Others include the Eurofighter Typhoon fighter jet and the European Space Agency's Ariane 5 rocket, highlighting the standard's continued relevance in both defense and space missions. Connectors are one of the physical layer components that need EMI and other requirements that enable the embedded networking systems onboard today's military air, land and space vehicles to operate in harsh environments.

MIL-STD-1553B remains relevant on in-service legacy military aircraft. (Image: PEI-Genesis)



This computer-generated illustration depicts NASA's Perseverance rover operating on the surface of Mars. Perseverance is one of several modern feats of aerospace engineering that leverages 1553B's resilience in extreme environments. (Image: NASA)

Twinax and triax connectors, like those offered by Cinch under the Trompeter brand, provide exceptional EMI protection and noise rejection through up to 90 percent shielding coverage and twisted-pair configurations. Similarly, Cinch offers a wide range of MIL-STD-1553 connectivity solutions, adapters, RFI caps, and terminators, as well as box bus couplers with 1–8 stubs and various fixed-length cable assemblies. These components are designed to meet stringent protocol requirements, ensuring low attenuation, precise impedance, and superior noise rejection—all critical for reliable data transmission in harsh environments.

In addition to connectors, MIL-STD-1553B cable assemblies are constructed with multiple layers of electrical shielding and environmental protection to withstand extreme temperatures, moisture, and mechanical shock. This combination of rugged design and advanced materials ensures consistent performance in mission-critical applications.

Hybrid architectures, where MIL-STD-1553B operates alongside higher-speed data protocols, are increasingly common to meet the demands of modern, data-intensive defense operations. While MIL-STD-1553B remains the trusted choice for critical command and control functions due to its deterministic reliability, newer protocols, such as Fibre Channel and ARINC 664 (AFDX) are employed in parallel to handle high-bandwidth data transfer.

For example, the F-22 Raptor leverages this hybrid approach, using 1553B for essential flight and weapons control, while faster protocols manage data from advanced radar, infrared, and electronic warfare systems. Similarly, the F-35 Joint Strike Fighter uses a combination of IEEE 1394 and Fibre Channel to manage the significant data generated by its advanced sensors, enabling real-time

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This is a different type of twinax connector provided by Cinch under the Trumpeter brand, capable of providing noise rejection through up to 90 percent shielding coverage in twisted pair configurations for 1553B systems. (Image: PEI-Genesis)

data fusion, threat detection and target acquisition, critical for modern combat effectiveness.

Real World Applications

MIL-STD-1553B's versatility and dependability has secured its position across various platforms. It forms the backbone of communication between flight controls, navigation systems and weapon systems in military aviation, such as the Eurofighter Typhoon. Ground vehicles, like the Bradley Fighting Vehicle, rely heavily on its robust architecture for onboard diagnostics and command functions. Space exploration missions, including NASA's Mars Perseverance Rover, which has been on Mars searching for signs of microbial life and other indications of habitability since February 2021, leverages MIL-STD-1553B due to its resilience in extreme environments. Missile systems like the Patriot missile use this 1553B for precise targeting data downloads and mid-flight coordination, exemplifying the standard's critical role in defense.

As defense sectors increasingly integrate AI-driven autonomous systems and advanced sensor networks, the deterministic nature of 1553B ensures precise, timely data delivery, essential in operational scenarios involving unmanned aerial vehicles (UAVs) like the MQ-9 Reaper and autonomous ground systems such as those featured on the robotic combat vehicle prototypes that the U.S. Army is currently evaluating.

The new HI-1592 development kit from Holt Integrated Circuits Inc., pictured here, is easily connected to an external 1553 controller board via an industry standard PMOD port. This port connects the controller digital transmit and receive signals needed to interface the transceiver with a MIL-STD-1553 bus, according to Holt's website. (Image: Holt Integrated Circuits, Inc.)

The Future of MIL-STD-1553B

While newer data bus standards, such as ARINC 664 (AFDX), Fiber Channel, and Ethernet-based protocols offer higher data rates and more advanced features — including deterministic data transmission, increased bandwidth, network scalability and support for real-time data transfer — MIL-STD-1553B's legacy of reliability and predictability ensures its ongoing relevance. Despite 1553B's five decades of relevance, there are still new embedded computing modules and components being developed to enable the use of the standard alongside newer high speed protocols and standard.

For example, in April 2024, defense embedded computing supplier Data Device Corporation introduced its new "Total-ACE CR" MIL-STD-1553 avionics data bus interface with integrated memory, dual transceivers and transformers in a plastic BGA package. The interface layer mitigates some of the inherent cyber security weaknesses that exists within the 1553 protocol amid its operation in today's increasingly connected aerospace and defense systems by integrating cyber resiliency at the protocol layer, independent of the host processor that the device or system is operating within. In October 2024, avionics data bus integrated circuits provider Holt Integrated Circuits introduced its radiation hardened ADK-1592, a development kit designed to help aerospace and defense systems integrators interface their HI1592 radiation hardened transceiver with MIL-STD-1553 protocol controllers or field programmable gate arrays (FPGAs), according to Holt's website. "The HI-1592 is latch-up immune and proven to withstand a single-event upset (SEU) with an LET of at least 67.7 MeV-cm2/mg. It is radiation tolerant to a total ionizing dose (TID) of 100 krad(Si) and is ideal for launch vehicle, high-altitude aircraft and low orbit satellite applications utilizing MIL-STD-1553 data bus communication," Holt notes in its release of the new development kit. "The device is also the World's first rad-hard MIL-STD-1553 transceiver to feature 1.8V, 2.5V and 3.3V compatible digital I/O, giving users more flexibility to interface with a broad range of FPGAs and controllers." These are just a few of the examples of new embedded modules and networking or interface components that continue to be developed to modernize 1553.

Modernized implementations, such as advanced bus controllers and enhanced remote terminals, further extend the standard's capabilities, allowing it to integrate with evolving digital infrastructure. These innovations not only maintain the standard's robustness but also open opportunities for enhanced functionality in next-generation defense systems. As a trusted partner, PEI-Genesis continues to support this evolution, providing state-of-the-art components that enhance the performance and longevity of MIL-STD-1553B systems. Our commitment to quality and customization ensures that a 50-year-old standard remains poised to support the next generation of aerospace and defense technology.

In an industry where failure is not an option, the enduring strength of MIL-STD-1553B — and the innovations keeping it relevant — serve as a powerful reminder that sometimes, the best way forward is to build on the foundations that have already proven their worth.

This article was written by Jamal Hagi, RF Engineer, PEI-Genesis (Philadelphia, PA). **For more information, visit www.peigenesis.com.**

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Are Defense Satellites Ready for Space-Based Laser Communications?

The Department of Defense (DoD) is developing technology for satellites to communicate via lasers. Laser communications could transmit data faster and more securely than traditional radio frequency communications.

DoD has made progress in developing this technology, but it has also faced delays and other issues—and hasn't fully demonstrated that it works in space. Despite these challenges, DoD plans to continue to develop and launch hundreds of satellites worth billions of dollars that require the use of laser communications.

In a 56-page report published in late February, the Government Accountability Office (GAO) made four new recommendations that would help DoD demonstrate the viability of space-based laser communications before investing in further development of the unproven technology.

Analysis of DoD documentation and feedback from laser communication technology developers shows that laser communications are an alternative to using radio frequency to transmit data in space and are capable of communicating at a rate 10 to 40 times higher than radio frequency data transmission rates, using a beam of light that is about 1,000 times narrower. In laser communications, data are transferred using laser beams from one satellite optical communication terminal (OCT) to another. In space-based laser communications, OCTs are affixed to a satellite and transmit data to other compatible OCTs or receivers. For two OCTs to transmit signals between one another, they must have compatible waveforms, unique characteristics of the laser beam that carry the data through space.

Based on our review of multiple DoD documents, interviews with DoD experts, and interviews with laser communications technology developers, we identified several key advantages and challenges in using laser communications systems on satellites. Advantages of using laser communications in space include the following:

- **Higher data rates.** Lasers can transmit data at higher rates than radio frequency. Higher data transmission rates are important for supporting selected new on-orbit technologies, such as new "high definition" instruments that collect larger volumes of data.
- **More secure.** OCTs use highly focused and narrow laser beams, making them less susceptible to detection and interception compared to traditional radio frequency signals.
- Lighter. OCTs are smaller, lighter, and require less power than traditional radio frequency communications equipment. For example, unlike radio frequency communications, OCTs do not require a large antenna to transmit and receive data.
- Not regulated. The use of radio frequencies is highly regulated to minimize interference among radio frequency applications. The US government does not regulate laser communications because the risk of interference is low.

Challenges of using laser communications in space include the following:

- Jitter. For laser communications to work, the transmitting and receiving systems need to minimize disturbance to the signal — referred to as jitter — caused by mechanical vibration and, in some cases, atmospheric turbulence. The amount of jitter in a signal affects the amount of data transmitted. If the jitter is significant, it may prevent the signal from being received and maintained. Because of the high level of precision required for laser communications, establishing a link is highly sensitive to disturbances that may cause jitter, including those that arise in the pointing, acquisition, and tracking (PAT) process and in the atmosphere.
- Pointing, acquisition, and tracking. PAT is the process by which two OCTs

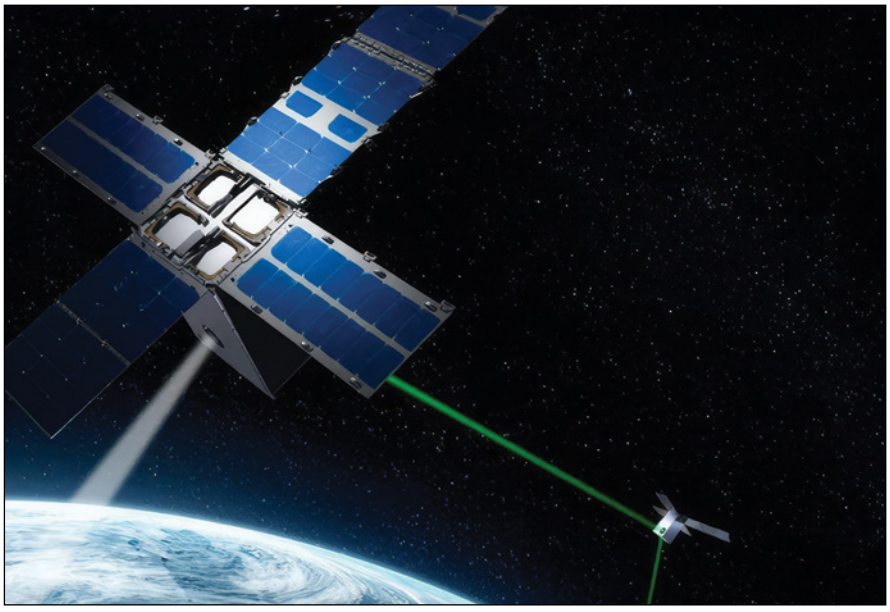
Image: Dragon Claws/Adobe Stock

point at one another to make initial contact, acquire a laser link, and track one another to maintain that link while data are transmitted. The OCT programming used to establish PAT must be intentionally designed to "speak" to one another. Achieving PAT requires that the design of satellites and the integration of the OCTs onto the satellites factor in how any vibrations may affect the level of jitter and the ability of the laser beam to transmit data.

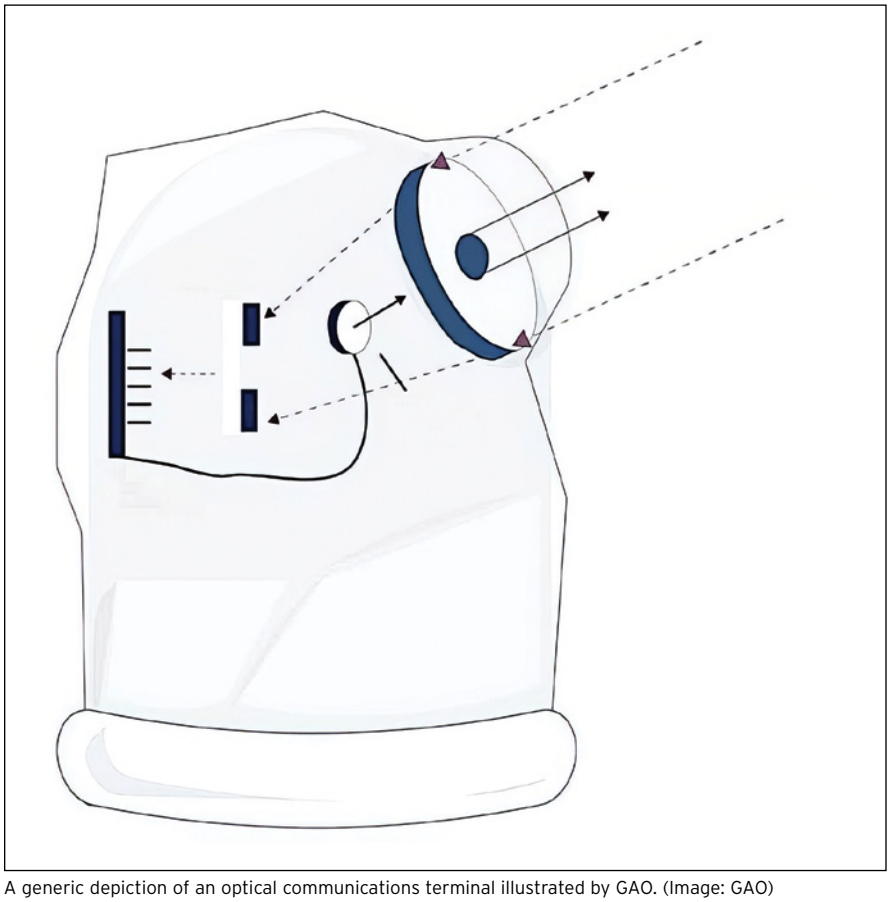
What GAO Found

The Space Development Agency (SDA) has taken steps to develop laser communications technology but has not yet fully demonstrated it in space. SDA has planned for iterations of satellites and related systems to be launched every 2 years, referred to as tranches. SDA's demonstration tranche — referred to as Tranche 0 or T0 — has faced development challenges and delays and has not fully demonstrated the capabilities expected from it.

For example, SDA planned to launch the first T0 satellites in 2022 but launched them in 2023 and 2024. Further, this initial group of satellites has not yet fully demonstrated laser communications technology in space. Specifically, as of December 2024, SDA reported that one of its four prime contractors in T0 had demonstrated three of the eight planned laser communications capabilities while another contractor had demonstrated one of the eight capabilities. The remaining two



In September, the Space Development Agency published this conceptual image of satellite crosslinks using lasers after demonstrating the ability of its optical communications terminals to link satellites together. (Image: SDA)



A generic depiction of an optical communications terminal illustrated by GAO. (Image: GAO)

contractors have not yet achieved any planned capabilities.

SDA's development approach thus far is inconsistent with the leading practices GAO identified. For example, although it has not yet achieved its requirements established for T0, SDA has now awarded contracts worth almost $10 billion for Tranche 1 and Tranche 2 (referred to as T1 and T2). Further, these two new tranches are expected to include increased technology complexity and significantly more satellites. While T0 was planned with 28 satellites, T1 and T2 are to have 165 and 264, respectively.

According to GAO's leading practices for product development, iterative development depends on demonstrating necessary capability in each iteration. SDA has described its efforts as iterative and noted that tranches need to work together to create the laser-based constellations. However, SDA officials also said that tranches are independent and delays in one will not delay the development schedule of future tranches. This approach means that SDA is proceeding through tranches and increasing the complexity of its development based on designs that have not yet met initial capabilities. As a result, SDA is at risk of unnecessarily investing in new efforts without yet delivering on promised capabilities intended to support critical missions.

Why GAO Did This Study

DoD is developing space-based laser technology to support large constellations of satellites for missions, including missile warning and data transport. This effort, known as the Proliferated Warfighter Space Architecture (PWSA), is a planned space-based design of at least 300-500 satellites in LEO. It is designed to include a Transport Layer with planned capabilities including transmitting data throughout the constellation and a Tracking Layer to provide critical missile warning and missile tracking capabilities.

Laser communications could improve capabilities beyond traditional radio frequency communications that DoD has traditionally used, in part, because data can be transmitted faster. These constellations are expected to cost nearly $35 billion through fiscal year 2029.

A Senate report includes a provision for GAO to assess DoD's efforts to develop these capabilities. GAO's report (1) describes SDA's efforts to develop laser communications technology, and (2) evaluates the extent to which SDA is following leading product development practices for its laser communications efforts.

GAO reviewed relevant documents; assessed SDA's schedule and plans against leading acquisition practices; conducted site visits to Air Force Research Lab, Naval Research Lab, and contractor facilities; and interviewed DoD, SDA, and Space Force officials and contractor representatives.

GAO's four recommendations, including that SDA demonstrate laser communications capabilities before finalizing efforts in T0 and before making further investments in subsequent tranches, are outlined below:

- The Secretary of the Air Force should ensure that the Director of the Space Development Agency demonstrates the minimum viable product for laser communications capability in space in PWSA's T0 and incorporates relevant lessons learned and corrective updates before proceeding with launch decisions for satellites in T1.
- The Secretary of the Air Force should ensure that the Director of the Space Development Agency creates and documents a link between demonstrating the minimum viable product for laser communications capability in space in PWSA's T1 and incorporates relevant lessons learned and corrective updates before proceeding further with launch decisions for satellites in T2.
- The Secretary of the Air Force should direct the Director of the Space Development Agency to ensure investment in PWSA is commensurate with development progress by demonstrating the minimum viable product of laser communications in space and incorporating lessons learned and corrective updates in T1 and, to the extent practicable, T2 before proceeding with the T3 effort.
- The Secretary of the Air Force should direct that the Director of the Space Development Agency documents and communicates PWSA's T0, T1, T2 and future tranche on-orbit test plans, including timelines and results, to relevant stakeholders.

This article was provided by materials from the Government Accountability Office (Washington D.C.) report entitled "Laser Communications: Space Development Agency Should Create Links Between Development Phases," it has been edited. **For more information, visit www.gao.gov.**

Microcomb Chips Could Improve Accuracy of GPS Systems

Today, our mobile phones, computers, and GPS systems can give us very accurate time indications and positioning thanks to the over 400 atomic clocks worldwide. All sorts of clocks - be it mechanical, atomic or a smartwatch - are made of two parts: an oscillator and a counter. The oscillator provides a periodic variation of some known frequency over time while the counter counts the number of cycles of the oscillator. Atomic clocks count the oscillations of vibrating atoms that switch between two energy states with very precise frequency.

Most atomic clocks use microwave frequencies to induce these energy oscillations in atoms. In recent years, researchers in the field have explored the possibility of using laser instead to induce oscillations optically. Just like a ruler with a great number of ticks per centimeter, optical atomic clocks make it possible to divide a second into even more time fractions, resulting in thousands of times more accurate time and position indications.

"Today's atomic clocks enable GPS systems with a positional accuracy of a few meters. With an optical atomic clock, you may achieve a precision of just a few centimeters. This improves the autonomy of vehicles, and all electronic systems based on positioning. An optical atomic clock can also detect minimal changes in latitude on the Earth's surface and can be used for monitoring, for example, volcanic activity," says Prof. Minghao Qi from Purdue University, co-author of a study recently published in Nature Photonics.

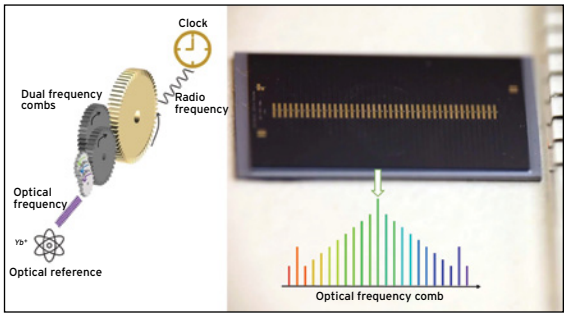
However, the optical atomic clocks that exist today are bulky and require complex laboratories with specific laser settings and optical components, making it difficult to use them outside lab environments, such as in satellites, remote research stations, or drones. Now, a research team at Purdue University, and Chalmers, has developed a technology that makes optical atomic clocks significantly smaller and accessible for more widespread use in society.

System Miniaturized by Microcombs

The core of the new technology, described in a recently published research article in Nature Photonics, are small, chip-based devices called microcombs. Like the teeth of a comb, microcombs can generate a spectrum of evenly distributed light frequencies.

"This allows one of the comb frequencies to be locked to a laser frequency that is in turn locked to the atomic clock oscillation," says Minghao Qi.

While the optical atomic clocks offer much higher precision, the oscillation frequency is at hundreds of THz range — a frequency too high for any electronic circuits to "count" directly. But the researchers' microcomb chips were able to solve the problem — while enabling the atomic clock system to shrink considerably.



Like the teeth of a comb, a microcomb consists of a spectrum of evenly distributed light frequencies. Optical atomic clocks can be built by locking a microcomb tooth to a ultranarrow-linewidth laser, which in turn locks to an atomic transition with extremely high frequency stability. That way, frequency combs act like a bridge between the atomic transition at an optical frequency and the clock signal at a radio frequency that is electronically detectable for counting the oscillations – enabling extraordinary precision. The researchers' photonic chip, on the right hand side of the image, contains 40 microcombs generators and is only five millimeters wide. (Image Illustration: Kaiyi Wu)

"Fortunately, our microcomb chips can act as a bridge between the optical signals of the atomic clock and the radio frequencies used to count the atomic clock's oscillations. Moreover, the minimal size of the microcomb makes it possible to shrink the atomic clock system significantly while maintaining its extraordinary precision," says Victor Torres Company, Professor of Photonics at Chalmers and co-author of the study.

Solving the Challenge of Self-Reference

Another major obstacle has been achieving simultaneously the "self-reference" needed for the stability of the overall system and aligning the microcomb's frequencies exactly with the atomic clock's signals.

"It turns out that one microcomb is not sufficient, and we managed to solve the problem by pairing two microcombs, whose comb spacings, i.e. frequency interval between adjacent teeth, are close but with a small offset, e.g. 20 GHz. This 20 GHz offset frequency will serve as the clock signal that is electronically detectable. In this way, we could get the system to transfer the exact time signal from an atomic clock to a more accessible radio frequency, " says Kaiyi Wu, the leading author of the study at Purdue University.

The innovation could pave the way for mass production, making optical atomic clocks more affordable and accessible for a range of applications in society and science. The system that is required to "count" the cycles of an optical frequency requires many components besides the microcombs, such as modulators, detectors and optical amplifiers. This study solves an important problem and shows a new architecture, but the next steps are to bring all the elements necessary to create a full system on a chip.

"We hope that future advances in materials and manufacturing techniques can further streamline the technology, bringing us closer to a world where ultra-precise timekeeping is a standard feature in our mobile phones and computers," says Victor Torres Company.

Finally, the authors wish to pay tribute to the late Professor Andrew Weiner, who oversaw the research project upon which this work is based, but passed away before the publication.

This article was written by Lovisa Håkansson, Communications Partner, Chalmers University of Technology (Gothenburg, Sweden). **For more information, contact Victor Torres, at torresv@chalmers.se.**

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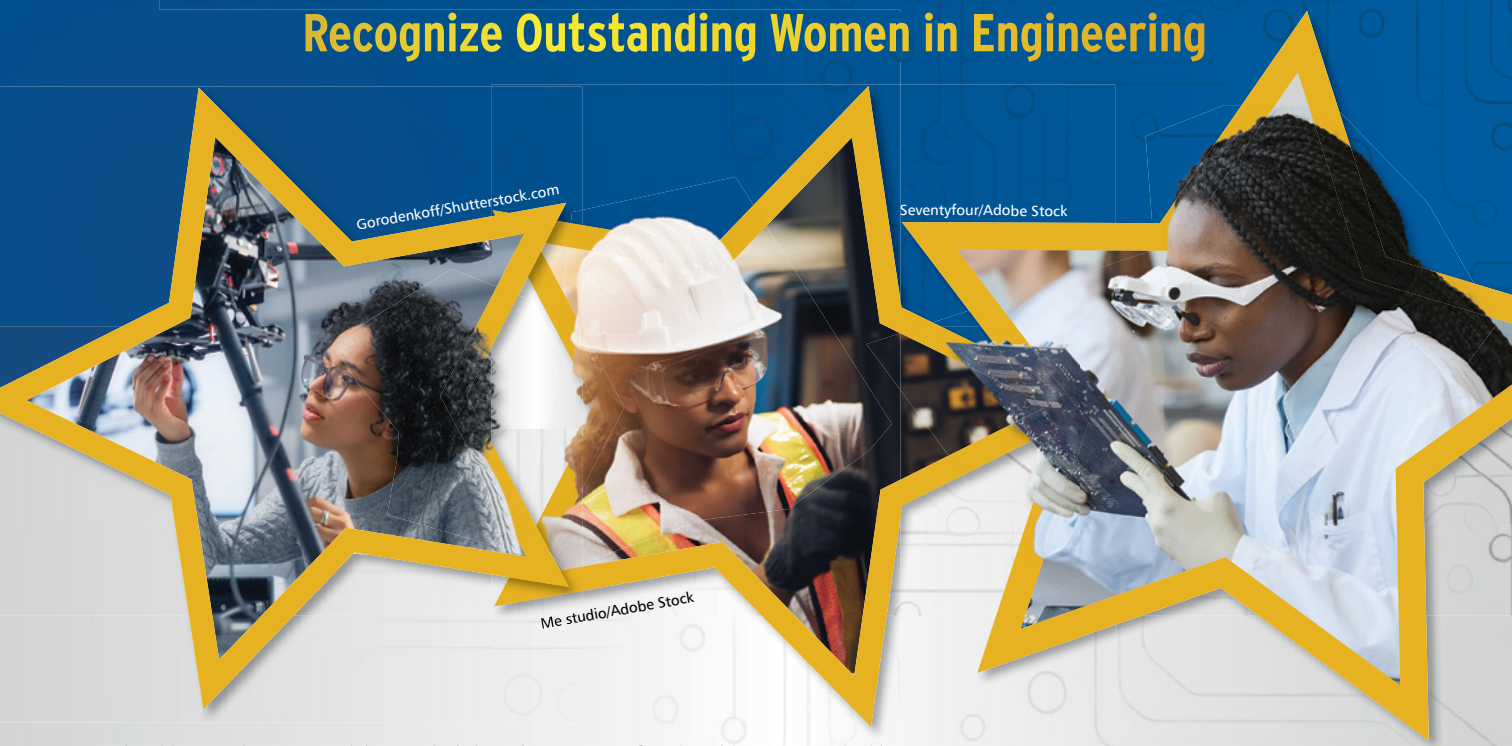

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Thermoelectric Generators Could Convert Waste Heat to Clean Energy in Jet Engines and Spacecraft

An Army-funded research project has led to the development of more efficient materials for developing thermoelectric generators that convert waste heat to clean energy for a variety of applications.

The Pennsylvania State University, University Park, PA

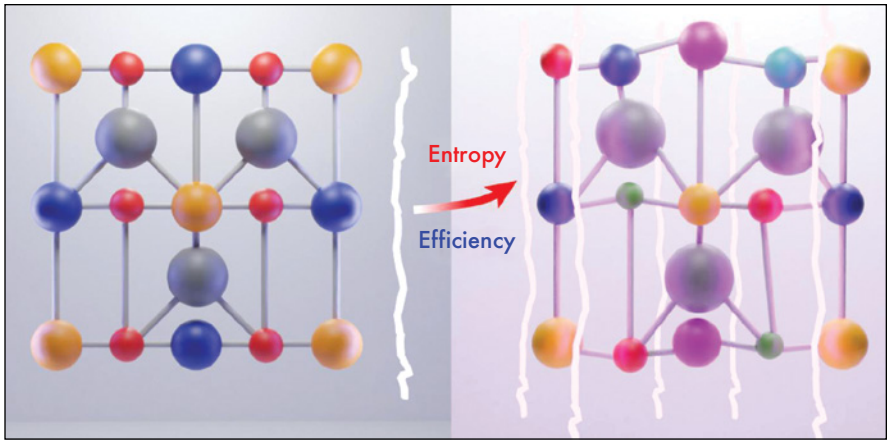
Thermoelectric generators that can convert waste heat to clean energy could soon be as efficient as other renewable energy sources, like solar, according to a team led by Penn State scientists. Using high-entropy materials, the researchers created more efficient thermoelectric materials than previously possible, an advancement that they said could even help make long-distance space exploration possible.

In a study partially funded by the U.S. Army with results published in the journal Joule last year, the researchers demonstrated how thermoelectric devices — including the radioisotope thermoelectric generators that produce energy for NASA's space exploration vehicles — can convert differences in temperature to electricity. When they are placed near a heat source – like a steam pipe in a power plant – charge carriers, like electrons, move from the hot side to the cold side, producing an electric current.

Current commercially available devices boast 5 percent to 6 percent efficiency. The researchers used their new fabrication approach to create a prototype that reached 15 percent conversion efficiency. The improved efficiency means that existing devices could shrink by 200 percent and still produce the same energy, or same-sized device could produce 200 percent energy, the researchers said.

"These findings show a new direction in how we can improve thermoelectric devices to be really efficient," said Bed Poudel, research professor in the Department of Materials Science and Engineering at Penn State and co-author on the study. "Our work provides a new avenue toward creating very exciting thermoelectric materials and could lead to even greater advances with future material development."

The Penn State team previously used half-Heusler alloys — a special class of materials that are good at generating thermoelectric power at medium-high temperatures — to improve device performance. These materials are typically alloys made of three metallic elements, sometimes with dopants, or small amounts of other materials, added to boost performance.



This artistic illustration depicts the unique arrangement of atoms in high-entropy thermoelectric materials. By incorporating a diverse mix of elements, these materials tap into a vast composition space, allowing for tuning of electrical and phonon properties, which enhances their thermoelectric performance as compared to conventional thermoelectric materials. (Image: Provided by Wenjie Li and Subrata Ghosh. All Rights Reserved.)

In the new work, the scientists turned to high-entropy half-Heusler materials. These alloys, which are made of at least five principal elements in a single crystalline structure, boast the same properties found in half-Heusler materials but enhanced.

"What we did in this work was successfully integrate high-entropy engineering into a half-Heusler system," said Wenjie Li, Associate Research Professor at Penn State and a co-corresponding author of the study. "With conventional compounds, you may have 100 options to make different chemical compositions. But when we use the high-entropy concept, we can make maybe thousands of chemical compositions in order to alter the material properties."

The scientists said using high-entropy materials with more atoms means the crystalline structures are more disordered and charge carriers take longer to move through the material, lowering its thermal conductivity. The additional atoms are selected in such a way that the material maintains a higher power factor, a measure of how efficiently an electrical system can convert power into useful work.

"In this concept, we can simultaneously maintain a high-power factor and get a low thermal conductivity to maximize the figure of merit, which is a measure of the materials' effectiveness," said Subrata Ghosh, a postdoctoral scholar at Penn State and lead author of the study. "High-entropy engineering can be incorporated with conventional approaches to improve the figure of merit further in any class of thermoelectric materials."

The new thermoelectric material achieved a record high figure of merit of 1.50 at a temperature change of 1,060 degrees Kelvin, or roughly 1,448 degrees Fahrenheit. That represents a 50 percent increase from current cutting-edge materials, the scientists said.

"High-entropy materials are often used in high-temperature refractory applications like jet engines or hypersonic vehicles, but this is the first time they have

been used to develop a superior half-Heusler thermoelectric system," Li said.

The work has implications for creating more efficient devices for waste heat recovery in industrial settings. Recovering this waste heat and using it to provide electricity can reduce fossil fuel consumption. And because they have no moving parts and produce no chemical reactions or emissions, thermoelectric devices offer a promising source of clean energy, the scientists said.

Thermoelectric devices resemble a table with two legs — one leg made of p-type and one of n-type semiconductor material. The current study only applies to the p-type material, and the scientists said further work to apply this to the n-type could result in additional increases in efficiency.

"If we can implement this to a wider class of thermoelectric materials and continue getting good figures of merit, we can really push the conversion efficiency toward 20 percent or more," Poudel said. "That would be very competitive with solar energy or other technologies for solid state power generation. That is the exciting part of it — to see what this can lead to in future material development."

The researchers were part of a team that published a follow up study based on their results in January 2025 in the journal ACS Applied Materials & Interfaces that takes their research a step further. The January study outlines a proof-of-concept design for a prototype thermoelectric generator device that could be used to convert wasted heat into clean energy in autonomous and long-range aerial platforms.

This article was written by Matthew Carroll, Science Writer, Penn State University. It has been edited. For more information, contact Patrica Craig, plc103@psu.edu.

Improving Electric Propulsion Thrusters for Future Spacecraft Missions

Two aerospace engineering researchers have published findings that could help optimize the integration of electric propulsion into spacecraft systems.

University of Virginia, Charlottesville, VA

Go faster, farther, more efficiently.

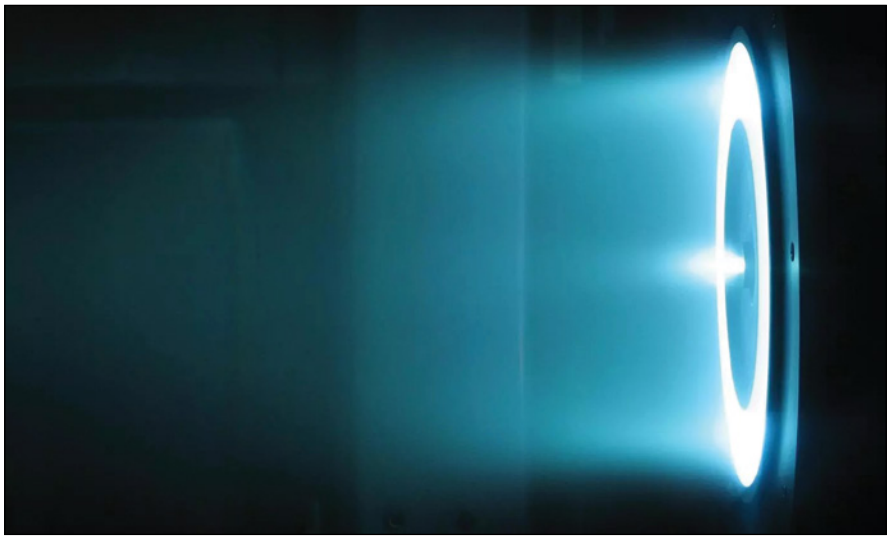
That's the goal driving spacecraft propulsion engineers like Chen Cui, a new assistant professor at the University of Virginia School of Engineering and Applied Science. Cui is exploring ways to improve electric propulsion thrusters — a key technology for future space missions.

"In order to ensure the technology remains viable for long-term missions, we need to optimize EP integration with spacecraft systems," Cui said.

Working with his former adviser, University of Southern California professor Joseph Wang, Cui published findings recently in *Plasma Sources Science and Technology* that provide fresh insights into electron kinetic behavior within plasma beams, perhaps revealing the "shape" of things to come.

Cui focuses his research on understanding how electrons — tiny, fast-moving charged particles — behave in the plasma beams emitted by EP thrusters.

"These particles may be small, but their movement and energy play an important role in determining the macroscopic dynamics of the plume emitted from the electric propulsion thruster," he said.



Pictured is a 6 kW Hall thruster in operation at the NASA Jet Propulsion Laboratory. (Image: NASA-JPL/CalTech)

By studying these microscopic interactions, Cui aims to better understand how the plume of plasma emitted interacts with the spacecraft itself.

Electric propulsion works by ionizing a neutral gas, usually xenon, and then using electric fields to accelerate the resulting ions. The ions, now forming a high-speed plasma beam, push the spacecraft forward.

Compared to chemical rockets, EP systems are much more fuel-efficient, enabling spacecraft to travel farther while carrying less fuel. These systems are often powered by solar panels or small nuclear reactors, making them

ideal for long missions in space, such as NASA's Artemis program, which aims to return humans to the moon, and eventually send astronauts to Mars and beyond.

However, the plume emitted by the thrusters isn't just exhaust — it's the lifeline of the entire propulsion system. If not well understood, the plume can cause unexpected problems. Some particles may flow backward toward the spacecraft, potentially damaging important components on the craft, such as solar panels or communication antennas.

"For missions that could last years, EP thrusters must operate smoothly and consistently over long periods of time," Cui said. This means scientists and engineers must have a deep understanding of how the plasma plume behaves in order to prevent any potential damage.

What the Research Found

Cui specializes in building advanced computer simulations to study how plasma behaves in EP thruster plasma flows. These aren't just any simulations. They're powered by modern supercomputers and use a method called Vlasov simulation, an advanced "noise-free" computational method.

The electrons in an EP beam don't behave exactly as predicted by simple models. They perform differently at different temperatures and speeds, creating distinct patterns.

Being able to precisely see the complexity of electron interactions, while factoring out data that confuse the bigger picture, is key.

"The electrons are a lot like marbles packed into a tube," Cui said. "Inside the beam, the electrons are hot and move fast. Their temperature doesn't change much if you go along the beam direction. However, if the 'marbles' roll out from the middle of the tube, they start to cool down. This cooling happens more in certain direction, the direction perpendicular the beam's direction."

In their most recent paper, they found the electron velocity distribution shows a near-Maxwellian [bell-curve-like] shape in the beam direction and what they describe as a "top-hat" profile in the transverse direction of the beam.

Additionally, Cui and Wang discovered that electron heat flux — the major way thermal energy moves through the EP plasma beam — primarily occurs along the beam's direction, with unique dynamics that had not been fully captured in previous models.

This article was written by Eric Williamson for the University of Virginia. For more information, contact eaw2s@virginia.edu.

A Satellite to Detect Short Gamma-Ray Burst Emissions

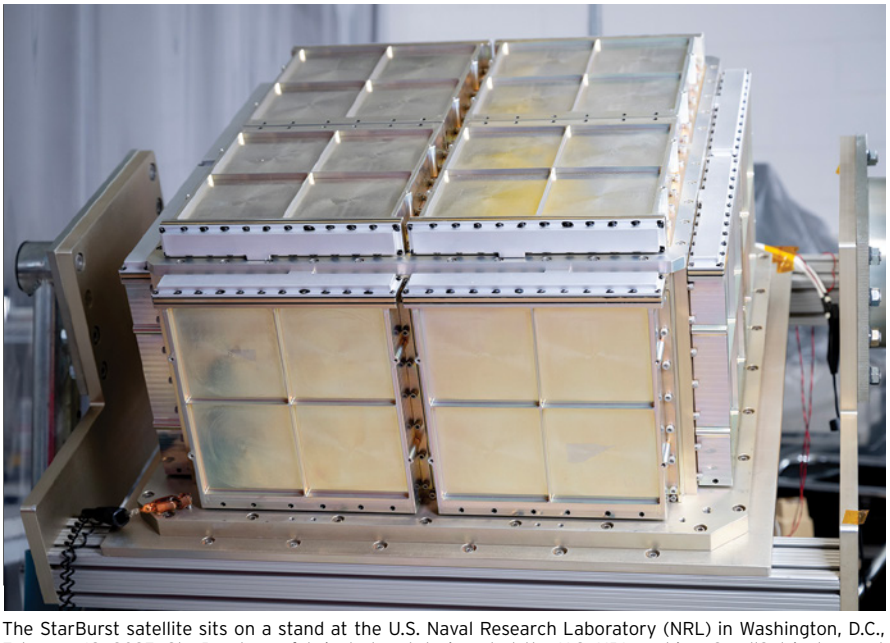
Physicists at the Naval Research Laboratory are collaborating with several universities throughout the U.S. to develop a small satellite that will detect the emission of short gamma-ray bursts.

U.S. Naval Research Laboratory, Washington D.C.

The U.S. Naval Research Laboratory (NRL), in partnership with NASA's Marshall Space Flight Center (MSFC), has developed StarBurst, a small satellite (SmallSat) instrument for NASA's StarBurst Multimessenger Pioneer mission, which will detect the emission of short gamma-ray bursts (GRBs), a key electromagnetic (EM) signature that will contribute to the understanding of neutron star (NS) mergers.

NRL transferred the instrument to NASA on March 4 for the next phase, environmental testing. From there, the instrument will be integrated onto the spacecraft bus, followed by launch into Low Earth Orbit in 2027. StarBurst will be installed as a secondary payload via the Evolved Expendable Launch Vehicle Secondary Payload Adapter Grande interface with a mission duration of one year, with the option of extension.

"StarBurst represents a significant leap forward in gamma-ray astronomy," said Richard S. Woolf, Ph.D., Research Phys-



The StarBurst satellite sits on a stand at the U.S. Naval Research Laboratory (NRL) in Washington, D.C., February 18, 2025. StarBurst was fabricated and designed at the U.S. NRL and is a SmallSat instrument that will detect gamma rays from events such as the mergers of dense stellar remnants called neutron stars. (Image: U.S. Navy)

icist with NRL's Space Science Division. "Our team at NRL has drawn upon years of expertise in detector development to create an instrument that is both highly sensitive and cost-effective. StarBurst will play a critical role in the exciting new era of multimessenger astronomy, allowing us to study neutron star mergers in unprecedented detail."

NS collisions are significant cosmic events and are recently understood as major producers of heavy elements such as gold and uranium. This process, known as nucleosynthesis, involves the formation of new atomic nuclei and occurs in various astrophysical settings, including neutron star mergers, supernovae, stellar burning, and the Big Bang.

The StarBurst Multimessenger Pioneer is a wide-field gamma-ray observatory focused on detecting short-duration bursts of gamma-rays that are produced following NS mergers that are observed via the gravitational waves that they produce. The combination of the gamma-ray and gravitational-wave signals provides fundamental insight into the parent stars and the physics of these extreme explosions. With an effective area four times greater than the Fermi Gamma-ray Burst Monitor – the most sensitive monitor currently on orbit – it will provide full coverage of the unobscured sky.

The enhanced sensitivity due to the large collecting area of the telescope will make StarBurst a vital partner to the gravitational wave network. This will significantly increase the detection rate of EM counterparts to NS mergers at a fraction of the cost of current gamma-ray missions.

The fundamental properties of the gamma-ray bursts measured by StarBurst will give scientists a representative picture of the ensemble properties of remnant explosions following NS mergers, for the first time.

The StarBurst Sensor Head comprised of 12 thallium-doped cesium iodide (CsI:Tl) scintillation detectors, each utilizing a custom array of low-mass, low-voltage silicon photomultipliers (SiPMs), is designed to allow StarBurst to detect GRBs in an energy range from 50 keV to 2000 keV, optimizing its sensitivity.

The instrument's design is inspired by NRL's successful technology demonstrator, Glowbug, led by J. Eric Grove, Ph.D., NRL Space Science Division Acting Superintendent, which recently concluded a highly productive mission on the International Space Station, detecting numerous GRBs and contributing to important astrophysical research.

StarBurst is a collaborative effort. MSFC leads the mission and partners with NRL, the University of Alabama Huntsville, the Universities Space Research Association, and the University of Toronto Institute for Aerospace Studies Space Flight Laboratory.

This article was written by Emily Winget for the Naval Research Laboratory. For more information, contact nrlpao@nrl.navy.mil.

In-Orbit Testing of Autonomous 'Swarm' Satellites

With 2D cameras and space robotics algorithms, astronautics engineers at Stanford have created a navigation system able to manage multiple satellites using visual data only. They recently tested it in space for the first time.

Stanford University, Stanford, CA

Someday, instead of large, expensive individual space satellites, teams of smaller satellites – known by scientists as a "swarm" – will work in collaboration, enabling greater accuracy, agility, and autonomy. Among the scientists working to make these teams a reality are researchers at Stanford University's Space Rendezvous Lab, who recently completed the first-ever in-orbit test of a prototype system able to navigate a swarm of satellites using only visual information shared through a wireless network.

"It's a milestone paper and the culmination of 11 years of effort by my lab, which was founded with this goal of surpassing the current state of the art and practice in distributed autonomy in space," said Simone D'Amico, associate professor of aeronautics and astronautics and senior author of the study. "Star-

An artist's illustration of an autonomous satellite swarm. (Image: NASA/Blue Canyon Technologies)

ling is the first demonstration ever made of an autonomous swarm of satellites."

The test is known as Starling Formation-Flying Optical Experiment, or StarFOX. In it, the team successfully navigated four small satellites working in tandem using only visual information gathered from onboard cameras to calculate their trajectories (or orbits).

All the Angles

D'Amico described the challenge as one that has driven his team for more than a decade. "Our team has been advocating for distributed space systems since the lab's inception. Now it has become mainstream. NASA, the Department of Defense, the U.S. Space Force – all have understood the value of multiple assets in coordination to accomplish objectives which would otherwise be impossible or very difficult to achieve by a single spacecraft," he said. "Advantages include improved accuracy, coverage, flexibility, robustness, and potentially new objectives not yet imagined."

Robust navigation of the swarm presents a considerable technological challenge. Current systems rely on the Global Navigation Satellite System (GNSS), requiring frequent contact with terrestrial systems. Beyond Earth's orbit, there is the Deep Space Network, but it is relatively slow and not easily scalable to future endeavors. What's more, neither system can help satellites avoid what D'Amico calls "non-cooperative objects" like space debris that might knock a satellite out of commission.

The swarm needs a self-contained navigation system that allows a high degree of autonomy and robustness, D'Amico said. Such systems are likewise made more attractive by minimal technical requirements and financial costs of today's miniaturized cameras and other hardware. The cameras used in the StarFOX test are proven, relatively inexpensive 2D cameras called star-trackers found on any satellite today.

"At its core, angles-only navigation requires no additional hardware even when used on small and inexpensive spacecraft," D'Amico said. "And exchanging visual information between swarm members provides a new distributed optical navigation capability."

Written in the Stars

StarFOX combines visual measurements from single cameras mounted on each satellite in a swarm. Similar to a mariner of old navigating the high seas with a sextant, the field of known stars in the background is used as reference to extract bearing angles to the swarming satellites. These angles are then processed onboard through accurate physics-based force models to estimate the position and velocity of the satellites with respect to the orbited planet – in this case, Earth, but the moon, Mars, or other planetary objects would work as well.

StarFOX employs the Space Rendezvous Lab's angles-only Absolute and Relative Trajectory Measurement System – ARTMS, for short – which integrates three new space robotics algorithms. An Image Processing algorithm detects and tracks multiple targets in images and computes target-bearing angles – the angles at which objects, including space debris, are moving toward or away from each other. The Batch Orbit Determination algorithm then estimates each satellite's coarse orbit from these angles. Last but not least, the Sequential Orbit Determination algorithm refines swarm trajectories with the processing of new images through time to potentially feed autonomous guidance, control, and collision avoidance algorithms onboard.

Data is shared over an inter-satellite communication link (or wireless network). It is all used to calculate robust absolute and relative position and velocity to a remarkable degree of accuracy without GNSS. Under the most challenging conditions, using just a single observer satellite, StarFOX was able to calculate relative position – the position of individual satellites to one another – to within 0.5 percent of their distance. When multiple observers were added in, those error rates dropped to just 0.1 percent.

The Starling test was deemed promising enough that NASA has extended the project, now known as StarFOX+, through 2025 to further explore these improved capabilities and pave the way for future space situational awareness and positioning technologies.

This article was written by Andrew Myers for the Stanford School of Engineering. For more information, contact Jill Wu, jillwu@stanford.edu.

NanoAvionics Satellite Suffers Space Debris Impact, Selfie Image Shows Damage

In October 2024, Kongsberg NanoAvionics discovered damage to their MP42 satellite, and used the discovery as an opportunity to raise awareness on the need to reduce space debris generated by satellites.

Kongsberg NanoAvionics, Vilnius, Lithuania

Our MP42 satellite, which launched into low Earth orbit (LEO) two and a half years ago aboard the SpaceX Transporter-4 mission, recently took an unexpected hit from a small piece of space debris or micrometeoroid. The impact created a 6 mm hole, roughly the size of a chickpea, in one of its solar panels.

Despite this damage, the satellite continued performing its mission without interruption, and we only discovered the impact thanks to an image taken by its onboard selfie camera in October of 2024. It is challenging to pinpoint exactly when the impact occurred because MP42's last selfie was taken a year and a half ago, in April of 2023.

Whether this impact was from a micrometeoroid or a piece of space debris, the collision highlights the need for responsible space operations in orbit and makes

us reflect on satellite resilience against these types of events.

How Much Space Debris Is There In Orbit?

Today, nearly 3 million kg of man-made objects orbit within 2,000 km of Earth, including active and inactive satellites and rocket stages. A smaller amount of mass, about 60,000 kg, is in the remaining 9,000 objects currently being tracked by space surveillance sensors. Comparatively, only a total of 200 kg of meteoroid mass is present within 2,000 km of Earth's surface at any given moment.

According to data from NASA's Long Duration Exposure Facility (LDEF), launched in 1984, small particles in orbit are common. During its nearly six-year mission, the LDEF spacecraft recorded up to 140 significant impact craters per square meter each year, with impact craters ranging from 0.1 mm to 3 mm in diameter. While natural micrometeoroid collisions are relatively stable, human-made debris poses a unique challenge by accumulating over time.

Despite these seemingly large numbers, the International Space Station (ISS), the largest structure in orbit with the largest safety area of any spacecraft, which spans 4 by 50 by 50 kilometers (2.5 by 30 by 30 miles), has only performed 32 collision avoidance maneuvers to dodge space debris in 23 years between 1999 and 2022.

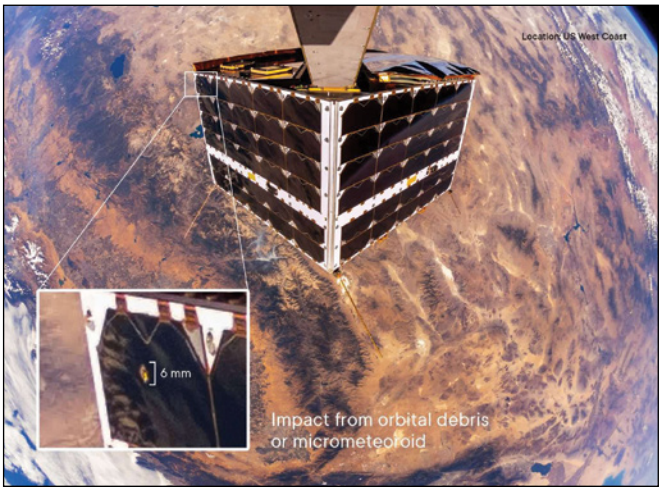
In our own experience, despite launching nearly 50 satellites over more than a decade, we have only had to perform a handful of collision avoidance maneuvers. Most recently, in 2024, our mission operators executed a sequence of three firings using the satellite's electric propulsion system, which lowered our customer's collision probability with another object by several orders of magnitude from 1.99e-4 to 5.94e-8.

However, with more satellites entering orbit each year, this low collision rate may not last if satellite manufacturers and operators do not take action to reduce the amount of generated debris today.

The Role of the Zero Debris Charter

As signatories and community members of the Zero Debris Charter, initiated by ESA, we're committed to the industry's ambitious goal of achieving zero debris by 2030. This Charter is a global initiative that, as of the time of writing, brings together more than 100 organizations worldwide to set measurable debris reduction goals, with targets built through open collaboration.

The Charter represents a shared vision for sustainable space operations, setting both high-level principles and technical targets to guide space safety efforts for years to come, emphasizing both immediate and long-term measures.



Kongsberg NanoAvionics was alerted to the space debris impact on their MP42 satellite, pictured here, by a selfie image taken by an onboard camera. (Image: Kongsberg NanoAvionics)

By joining this initiative, we're helping to ensure that NanoAvionics' satellites and those from our customers operate responsibly and contribute to a safer future in space.

Ways to Minimize Space Debris

We utilize space situational awareness platforms that use AI and machine learning to analyze space traffic data from multiple sources, providing precise collision predictions and optimized maneuver strategies. This ensures we can act quickly if any of our satellites are at risk. In addition to collision avoidance, we take several other steps to keep our orbits as clean as possible:

- Our satellites undergo rigorous total ionizing dose (TID), heavy ion, and proton beam radiation testing to ensure they operate reliably and don't become debris due to malfunctions caused by radiation.
- We use clean release mechanisms, such as burn wires and frangible bolts, for deploying solar panels, antennas, and other components to avoid producing debris.
- For satellites with mission lifetimes longer than five years, we equip them with propulsion systems for controlled deorbiting, reducing long-term debris.
- Some of the customer missions we enabled contribute to tracking and removing debris, actively helping to make space safer for all users.

Improving Satellite Design for Space Resilience

Our recent experience with the MP42 also brings up the discussion about how satellite design can reduce the impact of space debris on overall mission success.

A few examples could be considering positioning sensitive components, like star trackers, within the satellite frame or on sides that mostly face away from the satellite's velocity vector to reduce impact risks.

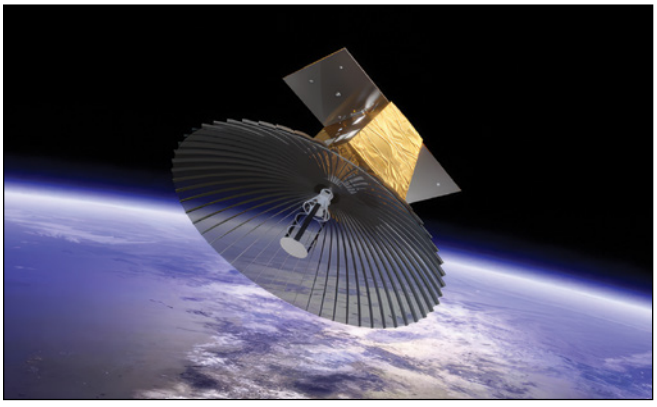
Additionally, examining how mission operations could reduce payload, such as camera optics, exposure to the primary flow of space debris. NASA's LDEF experiment we mentioned earlier showed that spacecraft encounter debris roughly 10 times more frequently on the side that is exposed to the satellite's velocity vector.

By adjusting satellite designs and concepts of operation (CONOPS) to protect vulnerable components, we can further improve our satellites' resilience in orbit.

This article was first written as a blog by Sarunas Kazlauskas, Content Manager, Kongsberg NanoAvionics. It has been edited. **For more information, visit www.nanoavionics.com.**

Synthetic Aperture Radar Satellites for UK Defense

Airbus Defense
London, UK
aeron.a.haworth@airbus.com
www.airbus.com



Airbus has been awarded the U.K. Ministry of Defense's (MoD) Oberon contract to design and build two Synthetic Aperture Radar (SAR) satellites with day-and-night, all-weather, space-based 'Intelligence, Surveillance and Reconnaissance' (ISR) capability.

The two Oberon satellites will boast active, ultra-high resolution SAR, providing freedom of action to the U.K. MoD and a greater operational capability to British and allied defense forces.

Minister for Defense Procurement and Industry Maria Eagle commenting on the contract award, said, "The contract for Oberon shows the UK's commitment to grow one of the most innovative and attractive space economies in the world and keep our competitive edge in space science and technology. Oberon will not only support armed forces personnel deployed globally, but also support highly skilled jobs, delivering on the government's growth mission."

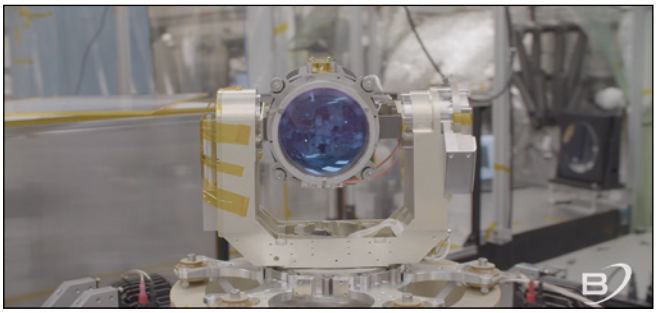
Airbus has worked with small and medium-sized enterprises (SMEs) across the U.K. to leverage innovative new technologies for the 400 kg satellites. The antennas for the spacecraft will be supplied by Oxford Space Systems, which has developed carbon fiber structures that stow away in very small volumes for launch but deploy into shape once in orbit. The 'wrapped rib' design will transmit and receive the radar pulses that are used to map the surface of the Earth.

The satellites will be designed, built and tested at Airbus' U.K.-based space facilities, including Stevenage and Portsmouth. The supporting satellite ground segment and geospatial intelligence capabilities will be developed at Airbus' facilities in Guildford, Newcastle, Newport and Chippenham. The system is expected to launch in 2027 and will contribute to U.K. information and decision superiority.

www.airbus.com

Breakthrough in Long-Haul Laser Communication Capabilities

BlueHalo
Albuquerque, NM
Ashley.Young@bluehalo.com
www.bluehalo.com



BlueHalo announced the successful milestone demonstration of its two-terminal long-haul, multi-orbit laser communication system. The achievement marks a significant breakthrough in the development of space-based laser communication technology with far-reaching implications for national security and commercial sectors.

During the demonstration, two laser communication optical terminals completed pointing, acquisition, and tracking sequences at transmit power levels supporting multi-orbit, space-to-space satellite crosslink amidst simulated challenges experienced in space environments, including jitter, extreme temperatures, and lack of atmosphere.

The demonstration's success highlights new capabilities for transferring high bandwidth data in space – enabling the secure exchange of more data at a faster rate across further distances, including LEO, MEO, GEO orbits and beyond. With the successful prototype demonstration in an operational environment, BlueHalo has matured its optical communication terminals to Technology Readiness Level (TRL) 6.

"I'm incredibly proud of our team, whose dedication to the mission has led to this milestone – developing a space-based laser communication capability that is orders of magnitude greater than existing technology on orbit today," said Mary Clum, President of the BlueHalo Product & Space Systems Portfolio. "With the technology validated, BlueHalo is ready to begin quickly producing these advanced optical terminals for deployment on satellites across all echelons of space. It's an urgent need to enhance our nation's security posture – in space and on the ground – and support the rapidly accelerating demand for rapid transport of high-bandwidth, mission-critical data. We're ready."

www.bluehalo.com

Electronically Steered Array Antennas for E2 Jets

Embraer
São José dos Campos, Brazil
embraer@ideal-axicom.com
www.embraer.com

Embraer has finalized an agreement with Intelsat to install its high-speed in-flight connectivity system on their E-Jet E2s during aircraft production. The system, with transmission speeds up to 275 Mbps, gives passengers a similar in-flight streaming and surfing experience to their home networks. The technology is the first multi-orbit satellite system to incorporate an Electronically Steered Array (ESA) antenna, according to Intelsat. The Intelsat ESA, which is offered as an option, will be available for line-fit on newly manufactured E2s by the end of this year.

"Intelsat is the first multi-orbit satellite in-flight connectivity system with an electronically steered array antenna to be installed at the Embraer factory, allowing passengers access to reliable, streaming connectivity starting immediately when aircraft enters revenue service," said Rob Baird, Director of OEM Programs at Intelsat. "Passengers on Embraer E2 aircraft will soon enjoy the same high speed internet access from the clouds that they enjoy at home, thanks to our wide coverage and low latency."

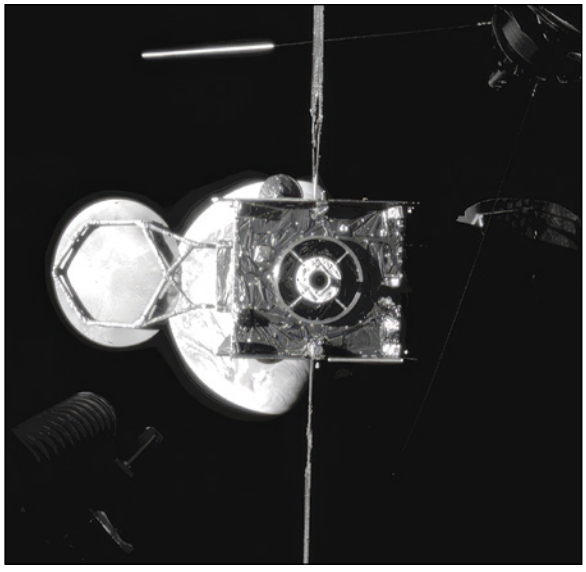
The ESA antenna itself is lightweight with a low profile (less than 3 inches) generates less drag compared to other designs, Intelsat claims. This helps minimize fuel consumption in keeping with Embraer's commitment to ensuring the E2's sustainability characteristics.

"Factory-installation of the Intelsat ESA is a good example of how we're making it easier for our customers to offer an improved passenger experience as soon as the aircraft is delivered," said Martyn Holmes, CCO, Embraer Commercial Aviation.

www.embraer.com

In-Orbit Commercial Spacecraft Undocking

Northrop Grumman
Dulles,VA
sophia.morris@ngc.com
www.northropgrumman.com



A Mission Extension Vehicle (MEV) developed by Northrop Grumman's Space Logistics LLC has successfully undocked with Intelsat's IS-901 satellite, completing its life extension service. This marks the first undocking between two commercial spacecraft in the geosynchronous earth orbit (GEO) graveyard. MEV-1 provided five years of life-extension services to IS-901, allowing Intelsat to operate this space-based asset beyond its design life. In 2020, MEV-1 successfully proved docking with IS-901 was possible in the GEO graveyard orbit and brought IS-901 back into operation in GEO. Northrop Grumman's Space Logistics has provided reliable service to the satellite operator for MEV-1's entire mission. MEV-2 will remain docked to Intelsat 10-02, providing life-extension for an additional four years – nearly doubling service from the original extension contract.

"The first-of-its kind technology that extended a satellite's life is paving the way for an entire infrastructure of future on-orbit satellite servicing missions for a variety of customers," said Rob Hauge, President, Space Logistics. "We are continuing to invest in next-generation capabilities to deliver the most technologically advanced servicing capabilities to support and maintain new and existing space-based assets."

Northrop Grumman's Space Logistics provides in-orbit satellite servicing to GEO satellite operators using its MEVs, which dock with customers' existing satellites to provide propulsion and attitude control needed to extend satellite service lives. Starting next year, Space Logistics next-generation systems will be able to provide expanded satellite services including on-orbit repairs, upgrades, refueling, debris removal, assembly and manufacturing.

www.northropgrumman.com

A Donut-Shaped In-Wheel Motor for Military Electric Vehicles

Finland-based startup Donut Defence is developing a new donut-shaped in-wheel electric motor for next generation military vehicles. Michael Waksman, CEO of Donut Defence, is the guest on this episode to explain how the Donut Motor could provide the type of architecture and performance necessary to power next-generation military electric vehicles.

https://www.mobilityengineeringtech.com/podcast/0525/in-wheel-motor

Defining the Use Case for Future Military Electric Vehicles

Mark Findlay, CEO of U.S.- and U.K.-based engineering consultancy Drive System Design (DSD), is the guest on this episode to explain why establishing definitive use cases and requirements is essential to unlocking the future potential of hybrid and all-electric military vehicles.

https://www.mobilityengineeringtech.com/podcast/0525/defining-the-use-case

Engineering the EL9: Electra's Ultra Short Hybrid-Electric Aircraft

Electra has been developing the EL9 as an "Ultra Short" aircraft powered by blown lift technology that only requires 150 feet for takeoff and landing. Marc Allen, CEO of Electra, is the guest on this episode to explain how the EL9's blown lift propulsion system works, and when it could be ready for commercial and military operations.

https://www.mobilityengineeringtech.com/podcast/0525/engineering-the-el9

How Amprius is Advancing Energy Density for Electric Aircraft Batteries

Amprius recently launched its new 450 Wh/kg SiCore™ lithium-ion battery, the most energy dense battery it has ever developed for electric aircraft and other mobility applications. Amprius CTO Dr. Ionel Ștefan is the guest on this episode to explain their latest battery energy density breakthrough and how they're preparing for mass production of their electric aircraft batteries.

https://www.mobilityengineeringtech.com/podcast/0525/amprius-advancing-energy

Listen to more podcasts at www.mobilityengineeringtech.com/met/webcasts/podcasts

Upcoming...

Webinars

Soar to New Heights: Simulation-driven Design for Safety in Electrified Aircraft Systems

Tuesday, June 17, 2025 at 9:00 am U.S. EDT

In the evolving landscape of aircraft electrification and progress towards advanced air mobility, safety has never been more paramount. Predicting the possibilities of various fault scenarios in a comprehensive manner from a system's perspective while ensuring faster time to market and achieving certification objectives is a delicate balance. This 45-minute webinar will explore how advanced simulation software can effectively pressure test a wide range of mission scenarios.

Speakers:

Jonas Verrière, Ph.D.
Staff Engineer,
Gamma Technologies

Felix Brenner
Senior Application Engineer,
Gamma Technologies

Please visit www.techbriefs.com/webinar555

Transforming Quality Management with Data-Driven Analytics

Friday, June 27, 2025 at 2:00 pm U.S. EDT

In today's competitive aerospace and defense (A&D) landscape, mid to large original equipment manufacturers face the critical challenge of relying on extensive supply chains to deliver high-quality products on time. With a diverse customer base, the pressure to optimize performance, reduce costs, and enhance product quality has never been greater. This 60-minute webinar will explore the imperative for change, highlighting how the traditional sequential supply chain model can no longer suffice.

Speakers:

Paul Granada
A&D Industry Consultant,
Dassault Systèmes

Francisco Rivera
Sr. Quality Industry Process Expert,
Dassault Systèmes

Please visit www.techbriefs.com/webinar561

Webinars on Demand!

Selecting RF Coaxial Cables for Space Flight

By evaluating key criteria, engineers can make informed decisions to enhance space mission success and the longevity of space systems. This 30-minute webinar explores the key considerations for selecting RF coaxial cables for space applications, emphasizing performance, reliability, and environmental resilience. It examines factors such as signal integrity, radiation resistance, thermal stability, multipaction, and weight constraints.

Speakers:

Maddiel Gonzalez
Vice President and CTO,
MegaPhase

William Pote
Founder and CEO,
MegaPhase

Please visit www.techbriefs.com/webinar551

Power Relays

Microchip (Chandler, AZ) announced the release of its BR235 and BR235D series of 25A QPL hermetically sealed electromechanical power relays that meet the requirements of MIL-PRF-83536 specification and ISO-9001 certification. This new series of power relays is specifically engineered for mission-critical commercial aviation, defense and space applications. These devices offer supply certainty coupled with global technical support. The series provides a 25A 3PDT rating and offers multiple variants for design flexibility. Options are available in suppressed or non-suppressed, coil voltages from 6–48 VDC and 115 VAC, mounting styles with and without mounting tabs in different orientations, straight or J-Hook terminal pin types, and tin or gold plating.

www.microchip.com

Spectrum Defender

In a message shared with the RF community, Sean Wallace of Spectra Lab (Dumfries, VA) explained that Bird Technologies, known for its X-COM division and the IQC line of RF recorders, is shifting its focus toward core competencies such as RF power measurement. This shift marks the end of an era for their widely used IQC line. To help the industry transition, Spectra Lab has introduced new features to its Spectrum Defender product. The most notable of these features is the ability to record directly in the X-COM file format, enabling users with existing X-COM workflows or large X-COM file libraries to continue their operations seamlessly. Furthermore, users of Bird's SpectroX analysis software will now be able to record new signals in Spectrum Defender and open them instantly in SpectroX, with no conversion needed.

www.spectrumdefender.com

Single Pair Ethernet Cable

PIC Wire & Cable's (Waukesha, WI) new Single Pair Ethernet (SPE) represents the next evolution in connectivity solutions for aerospace applications. The SPE has a compact and lightweight design that reduces weight and space requirements by up to 50 percent to four-pair Ethernet cables, enhancing fuel efficiency and reducing emissions. The E1G4222 cable revolutionizes aerospace networking by replacing traditional four-pair Ethernet cables with an advanced single-pair design. This breakthrough enables gigabit-speed data transmission with reduced space and weight requirements, all while ensuring superior signal integrity and durability.

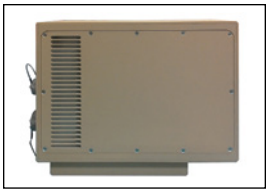
www.picwire.com

High Performance Recorder

Galleon Embedded Computing (Oslo, Norway) has completed comprehensive environmental qualification testing for their new high performance recorder (HPR). This milestone certification ensures reliable performance for intelligence, surveillance, and reconnaissance (ISR) operations, military training and debriefing, and airborne and marine surveillance applications in the most challenging operational environments. The server/network-attached storage device/recorder provides customers with a robust solution featuring up to 32TB of storage and 5GB/s recording speeds.

www.galleonec.com

SOSA Aligned ATR Enclosures



Pixus Technologies (Waterloo, Ontario) has developed new SOSA aligned ATR enclosures utilizing the 3U OpenVPX form factor. The various chassis platforms typically support 100GbE or higher speeds. The new ARINC 404 5/8 size ATRs from Pixus features customized I/O options and various SOSA slot profile options, including RF and optical interfaces through the backplane. For chassis management, the ATR has the option of implementing Pixus' SOSA aligned Tier 3 mezzanine-based solution that sits behind the backplane.

www.pixustechnologies.com

Next Generation Servers

Dedicated Computing (Waukesha, WI) announced its latest portfolio of high-performance servers powered by Intel® Xeon® 6 processors. Designed to meet the growing demands of AI, edge computing, and industrial workloads, this new portfolio delivers unparalleled scalability, efficiency, and processing power for OEMs and enterprises seeking cutting-edge performance. At the core of the latest server portfolio is the Intel® Xeon® 6 processor family. Featuring up to 86 cores per CPU, DDR5 memory support up to 6400 MT/s, and 96 lanes of PCIe Gen 5 connectivity, these processors enable seamless execution of compute-intensive and scale-out workloads.

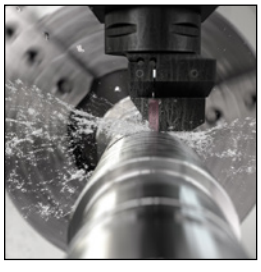
www.dedicatedcomputing.com

Uninterrupted Bevel Cutting

Lantek (Mason, OH) and ZINSER have jointly developed an innovative solution that revolutionizes bevel cutting in pre-cut parts. Traditionally, bevel cutting was performed within the nesting process, often causing issues such as collisions, cutting inaccuracies, or production slowdowns. The industry is now shifting towards a more efficient approach: first, parts are cut on a high-production machine, and then those requiring bevels are transferred to a dedicated bevel-cutting machine. Through a custom-developed postprocessor for ZINSER machines, Lantek's software uses sensory data to accurately calculate each part's position and orientation, automatically adjusting the cutting parameters to ensure precise execution.

www.lantek.com

CoroCut 2: New Parting and Grooving Geometries



Sandvik Coromant (Mebane, NC) is expanding its versatile CoroCut® 2 with a new -GL parting and grooving geometry, and an updated -CR parting-off geometry. This expansion in geometries will make a significant difference to workshops machining in hard-to-chip steels and in parting-off operations where a strong edge is needed. Featuring the most aggressive chip breaker in the CoroCut 2 concept, the new -GL geometry is ideal for workshops requiring better chip control in demanding ISO P components, such as low-carbon steel, clean steels and cold-forged automotive components. The -CR geometry is the first choice for parting-off operations at higher feeds or during intermittent cutting and is suitable for a wide range of materials.

www.sandvik.coromant.com

Direct Time of Flight LiDAR Sensor

Sony Electronics Inc. (Paramus, NJ) announced commercialization of the AS-DT1 LiDAR Depth Sensor. The AS-DT1 is the world's smallest and lightest LiDAR Depth Sensor structure measuring just 29mm × 29mm × 31mm (approximately 1.14 inch width × 1.14 inch height × 1.22 inch depth), excluding protrusions, and weighing only 50g (approximately 1.76 ounces). The AS-DT1 utilizes 'Direct Time of Flight (dToF)' LiDAR technology. The proprietary dToF ranging module, equipped with a Single Photon Avalanche Diode (SPAD) sensor, utilizes multiple ranging points for distance measurement, and can accurately measure distances in three dimensions: length, width, and depth.

www.pro.sony

Blackwell-Based VPX Computing Modules

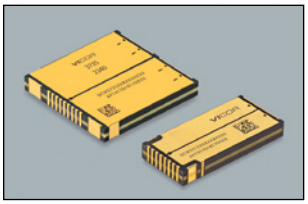
WOLF Advanced Technology (Aurora, Ontario) unveiled four NVIDIA® Blackwell-based VPX modules designed for mission-critical edge AI applications. Leveraging NVIDIA® Blackwell GPUs, these 3U and 6U VPX modules deliver unprecedented AI inference capabilities while operating in harsh environments. The WOLF-1636 redefines rugged AI processing with NVIDIA's Blackwell RTX 5000 embedded GPU, featuring 10,496 CUDA cores and 320 fifth-generation Tensor Cores. Its 24GB GDDR7 ECC memory achieves up to 896GB/s bandwidth — 55 percent faster than prior generations, enabling larger data sets to reach the GPU for real-time processing.

www.wolfadvancedtechnology.com

IQ-Core Software

Curtiss Wright Defense Solutions (Ashburn, VA) has announced enhancements to its IQ-Core® Software suite. IQ-Core Software is a software application designed for secure, tactical, and distributed network management – ideal for edge networks in disconnected, intermittent, and limited (DIL) environments. New IQ-Core software capabilities include: Enhanced security via support for smartcard and CAC multi-factor authentication; REST- based Application Programming Interfaces (API); Suite of powerful new features to enhance the management and maintenance of INTEGRITY™ Global Security (IGS) security appliances. The addition of support for the industry-standard REST API enables IQ-Core Software customers to easily integrate with third-party platforms.

www.curtisswrightds.com



DC-DC Converter Modules

Vicor's (Andover, MA) non-isolated, regulated DC-DC converter modules operate from a 40 – 60V input, generate a regulated 12V output, and are adjustable from 10V to 12.5V. They support up to 2000W and can be paralleled to attain higher power levels. The DCM has established a new benchmark for power density with a low-height, surface mount Converter housed in Package (SM ChiP), resulting in a 6x reduction in size over a conventional converter. With Vicor proprietary high frequency switching technology, these modules deliver high efficiency over all line and load conditions. They can be used to establish a 12V bus or used with legacy, downstream point-of-load (PoL) converters, and are ideally suited for bridging 48V and legacy 12V power buses in industrial, aerospace and defense, and high performance computing applications.

www.vicorpower.com

High Voltage DC-DC Converter

Crane A&E's (Lynwood, WA) new High Voltage DC-DC Converter provides customers an innovative, unmatched power conversion solution. Crane A&E has used its more than 60 years of electrical power expertise to develop a one-of-a-kind, highly-efficient, high-power density DC-DC power converter. Crane A&E's new converter is engineered to support multiple power sources and cooling options to meet and exceed customer demand. With tremendous flexibility, our new 4kW power converter can be paralleled to match customer needs. The converter's cooling modules also support liquid, fan or conduction cooling.

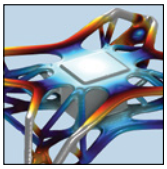
www.craneae.com

Non-Drip Cryogenic Epoxy

Master Bond's (Hackensack, NJ) EP29LP-SPND-3 is a two component, non-drip epoxy compound with a paste consistency that can be used for bonding and sealing applications. The system is electrically non-conductive and thermally insulative, with a thermal conductivity of approximately 0.2 W/(m•K) at room temperature. It withstands cryogenic temperatures and is serviceable in the range from 4K to 250 °F. EP29LPSPND-3 features a coefficient of thermal expansion of 45-50 x 10-6 in/in/°C, a tensile strength of 6,000-8,000 psi, and a Shore D hardness of 70-80. This system has a volume resistivity exceeding 1015 ohm-cm at 75 °F and a dielectric constant of 4.2 at 60 Hz.

www.masterbond.com

Product Spotlight



MULTIPHYSICS MODELING AND SIMULATION APPLICATIONS

COMSOL Multiphysics® is a software environment for creating physics-based models and standalone simulation apps. Add-on products provide specialized functionality for electromagnetics, structural, acoustics, fluid flow, heat transfer, and chemical simulations. Interfacing products offer a unified workflow with all major technical computing and CAD tools. COMSOL Compiler™ and COMSOL Server™ are used for deploying simulation applications to colleagues and customers. https://www.comsol.com/products

COMSOL, Inc.

THERMALLY CONDUCTIVE STRUCTURAL EPOXY

Master Bond Supreme 11AOHTLP is a thermally conductive, electrically insulating structural epoxy designed for bonding larger parts due to its relatively long working life of 60-90 minutes. This toughened formulation also withstands thermal cycling and offers a wide service temperature range from -112°F to +400°F (-80°C to 204°C). https://www.masterbond.com/tds/supreme-11aohtlp

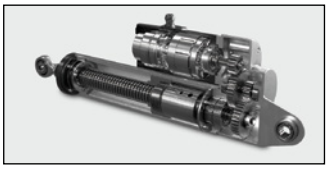
Master Bond

S-A2300 AI Supercomputer

Aitech (Chatworth, CA) announced a significant milestone in AI technology with the S-A2300 COTS AI supercomputer. Leveraging NVIDIA's GPGPU Orin architecture, the new groundbreaking AI supercomputer is specifically designed for Low Earth Orbit (LEO) missions and integrates exceptional computational power with advanced AI functionalities. The S-A2300 provides up to 2048 CUDA cores and 64 Tensor cores that reach up to 248 TOPS. The system also features two scalable, highly configurable, dedicated NVDLA (NVIDIA Deep-Learning Accelerator) engines that simplify integration and portability, as well as promote a standard way to design deep learning inference accelerators.

www.aitechsystems.com

Electro-Mechanical Actuator Subsystem



Regal Rexnord (Milwaukee, WI) is advancing the next generation of electro-mechanical actuators purpose-built for the unique requirements of aerospace and defense applications. The company's expanded offering in subsystems leverages the unique strengths of its trusted portfolio, spanning high-performance motors, rotary and oscillatory bearings, dynamic seals, resolvers, magnetics, ball and lead screws, clutches, and brakes. Solutions are designed and manufactured in-house at one or more of our 12 global AS9100-certified facilities, enabling accelerated transitions from prototyping to full-scale production.

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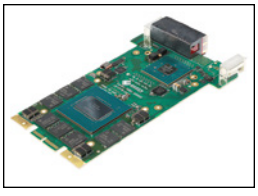
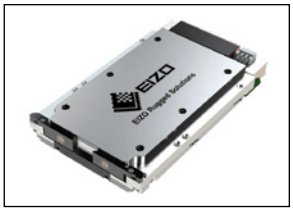


SOSA-Aligned 3U VPX GPGPU Card

AMETEK Abaco Systems (Huntsville, AL) is excited to introduce the GRA117S, a SOSA-aligned Open VPX 3U video graphics and GPGPU card. It's powered by the NVIDIA RTX™ GPU with 16 GB GDDR6 ECC memory and is designed to support AI and deep learning capabilities. Designed for extreme environments and mission-critical applications, the GRA117S offers a wide range of advanced features, including: NVIDIA RTX™ 5000 GPU (Ada Lovelace Architecture); 16 GB of GDD56 advanced graphics memory with error correction code (ECC); PCI Express Gen 4 connectivity support offering flexibility and ultra-fast data transfer speeds; SOSA slot profile 14.6.11 and 14.6.13 compatibility.

www.abaco.com

Condor GR6S-AD2000



EIZO (Orlando, FL) has introduced the Condor GR6S-AD2000 – a ruggedized 3U OpenVPX form factor video graphics and GPGPU card powered by the NVIDIA RTX™ 2000 Ada Generation Embedded GPU. The Condor GR6S-AD2000 is a SOSA®-aligned, I/O-intensive 3U VPX video capture solution designed for high-performance computing systems that require real-time video capture and AI-accelerated data processing. It supports up to six 12G-SDI video streams, including four dedicated inputs and two dedicated outputs. This flexible I/O architecture enables seamless multi-video ingestion, processing, and transmission, enhancing real-time situational awareness in mission-critical applications.

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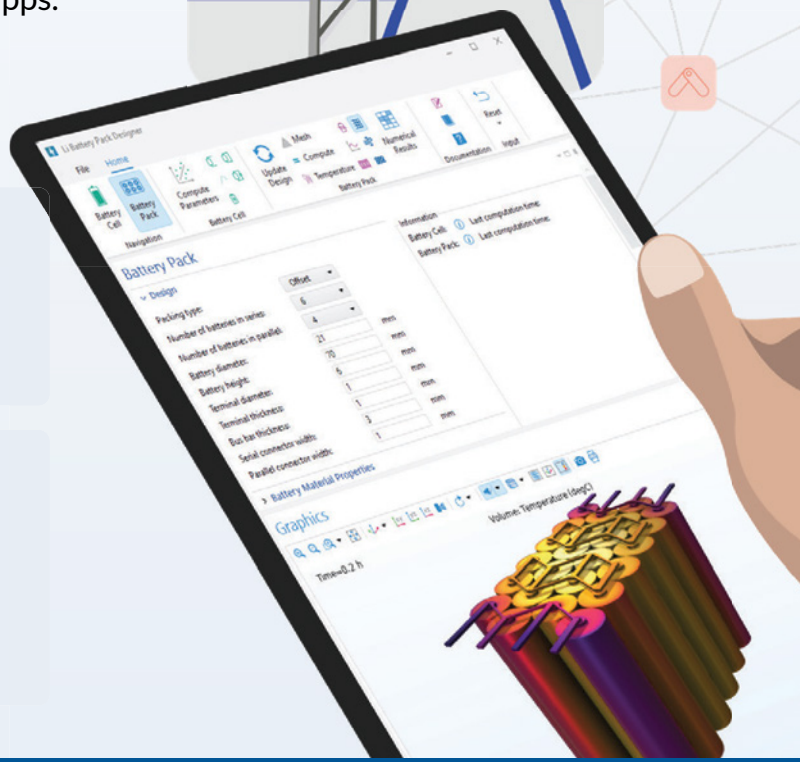

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